ASTM STANDARDS

on

OOD, WOOD PRESERVATIVES, AND RELATED MATERIALS

Sponsored by
ASTM COMMITTEE D-7
On Wood

SPECIFICATIONS
METHODS OF TESTING
DEFINITIONS OF TERMS

March, 1959

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March, 1959

FOREWORD

This compilation brings together in convenient form the various standards of the Society relating to wood and wood-base materials, including wood preservatives. Included are some 50 methods of test, specifications, and definitions of terms that have been prepared by Committee D-7 on Wood. In addition, a number of other specifications and methods, directly or indirectly relating to wood, developed by other technical committees of the Society are also presented.

Broadly, it is the function of the American Society for Testing Materials to aid in the promotion of knowledge of the materials of engineering, and the standardization of specifications and the methods of testing. These objectives are of course based on the well-established concept that an accurate knowledge of the properties of materials and of factors affecting strength and serviceability is essential to their efficient use, and further that the results obtained in any evaluation of physical or chemical properties of materials are directly related to and dependent on the methods employed. The wider use of well-established specifications and standard methods aids in the development of accurate data on a comparable basis among different research organizations and promotes the more efficient use of the materials of engineering.

Attention is called particularly in this compilation to the comprehensive methods presented for evaluating the strength and related properties of the various species of wood in the form of small clear specimens (ASTM Designation: D 143); to the methods of testing veneer, plywood, and other glued veneer constructions (ASTM Designation: D 805); and to the group of methods recently prepared in standard form for the complete chemical analysis of wood, ranging from the method of test for ash in wood to the method of test for alpha-cellulose in cellulosic materials.

The development of standards in the Society is carried on by its various technical committees. Activities in the study and development of specifications and tests for wood, wood-base materials, and wood preservatives are under the jurisdiction of its Committee D-7 on Wood. Committee D-7 was organized in 1904 and since that time has been actively engaged in the preparation of methods of tests and specifications in its field, and is continually reviewing and revising procedures to bring them into line with the new developments in testing methods, techniques, and equipment.

Committee D-7 carries on its activities under the general rules and regulations of the Society, which provide for balanced representation of membership among producers, consumers, and general interests. This classification of membership is the key to the adequate consideration of different viewpoints in the preparation of test procedures and specifications, and to the wide acceptance of the standards of the Society.

The officers of the ASTM Committee D-7 on Wood are L. J. Markwardt, Chairman and W. A. Oliver, Secretary. Inquiries regarding the activities of Committee D-7 may be addressed to the officers, or to the American Society for Testing Materials, 1916 Race Street, Philadelphia 3, Pa.

March, 1959

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This publication is one of a series of special compilations of ASTM standards relating to specific industrial fields. Of particular interest to the users of this publication is the compilation:

	PRICE
ASTM Standards in Building Codes, 1066 pages (May, 1958)	$8.00

Also of interest are the following:

Methods of Testing Building Constructions, STP No. 166, 136 pages (February, 1955)	$2.75
Wood as an Engineering Material (Marburg Lecture, 1943), by L. S. Markwardt, 64 pages	$1.00
Wood for Marine Use and its Protection from Marine Organisms, STP No. 200, 56 pages (June, 1957)	$2.00
Full Scale Tests on House Structures, STP No. 210, 64 pages (August, 1957)	$2.50

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CONTENTS

ASTM STANDARDS[a] RELATING TO WOOD, WOOD-BASE MATERIALS, AND WOOD PRESERVATIVES

Methods for Evaluating Mechanical and Physical Properties

Wood, Veneer, Plywood, and Fiber Building Boards

Methods of Test for: PAGE

*D 143 – 52. Small Clear Specimens of Timber 1
*D 805 – 52. Veneer, Plywood, and Other Glued Veneer Constructions 57
*D 1037 – 56 T. Building Fiberboards, Evaluating Properties of 81
*D 198 – 27. Timbers in Structural Sizes, Static Tests 100
D 1036 – 58. Wood Poles, Static Tests 116

Building Constructions and Structural Units

Methods of Test for:

E 72 – 55. Panels for Building Construction, Conducting Strength Tests 321
E 73 – 52. Truss Assemblies 351
D 1101 – 58. Integrity of Glue Joints in Laminated Wood Products for Exterior Service 136

Recommended Practice for:

E 90 – 55. Airborne-Sound Transmission Loss of Building Floors and Walls, Laboratory Measurement of 356

Methods for Chemical Analysis of Wood

Methods of Test for:

D 1102 – 56. Ash in Wood 139
D 1103 – 55 T. Alpha-Cellulose in Wood 141
D 1104 – 56. Holocellulose in Wood 144
D 1105 – 56. Extractive-Free Wood, Preparation of 146
D 1106 – 56. Lignin in Wood 148
D 1166 – 55 T. Methoxyl Groups in Wood and Related Materials 151
D 1107 – 56. Alcohol-Benzene Solubility of Wood 156
D 1108 – 56. Ether Solubility of Wood 158
D 1109 – 56. One Per Cent Caustic Soda Solubility of Wood 160
D 1110 – 56. Water Solubility of Wood 162

Definitions of Terms Relating to Wood

Definitions of Terms Relating to:

*D 9 – 30. Timber 164
*D 1038 – 52. Veneer and Plywood 169
*D 1165 – 52. Domestic Hardwoods and Softwoods, Nomenclature of 175
D 1554 – 58 T. Wood-Base Fiber and Particle Panel Materials 180

---

* Approved as **American Standard** by the American Standards Association.

[a] Standards marked T are designated by the Society as Tentative to indicate either a new standard or an older one that may have been recently revised. There need be no distinction in their use from that of other standards of the Society.

For Contents in Numeric Sequence, see p. ix.

Methods of Structural Grading and Specifications for Wood and Timbers

Methods for:

PAGE
*D 245 – 57 T. Establishing Structural Grades of Lumber 184

Specifications for:

D 25 – 58. Timber Piles, Round 219
D 52 – 58 T. Wood Paving Blocks for Exposed Platforms, Pavements, Driveways, and Interior Floors Exposed to Wet and Dry Conditions .. 224
*D 1031 – 55. Wood Block Flooring, End-Grain, Creosoted, for Interior Use ... 227
*D 1324 – 57 T. Modified Wood 231
D 358 – 55. Wood to be Used as Panels in Weathering Tests of Paints and Varnishes 236

Fire Tests of Building Materials and Constructions

Methods of Test for:

E 160 – 50. Combustible Properties of Treated Wood by the Crib Test 363
E 69 – 50. Combustible Properties of Treated Wood by the Fire-Tube Apparatus 368
*E 119 – 58. Fire Tests of Building Construction and Materials 374
*E 152 – 58. Fire Tests of Door Assemblies 385
E 84 – 50 T. Fire Hazard Classification of Building Materials 390
E 136 – 58 T. Noncombustibility of Building Materials, Defining 393

Wood Preservatives

Specifications for:

D 390 – 53. Creosote 239
D 391 – 53. Creosote – Coal Tar Solution 241
D 432 – 50. Zinc Chloride 243
D 1032 – 50. Chromated Zinc Chloride 244
D 1271 – 56. Copperized Chromated Zinc Chloride 245
D 1325 – 56. Copper Arsenite, Ammoniacal 246
D 1272 – 56. Pentachlorophenol 247
D 1034 – 50. Tanalith 248

Methods of Test for:

D 38 – 33. Sampling and Testing Creosote 249
D 367 – 49. Benzene-Insoluble Matter in Creosote 263
D 168 – 30. Coke Residue of Creosote 252
D 246 – 49. Distillation of Creosote 254
*D 158 – 54. Distillation of Gas Oil and Similar Distillate Fuel Oils 402
*D 93 – 58 T. Flash Point by Pensky-Martens Closed Tester 260
*D 139 – 49. Float Test for Bituminous Materials 399
*D 287 – 55. Gravity, API, of Petroleum and Its Products (Hydrometer Method) 407
D 368 – 33. Specific Gravity of Creosote 266
D 369 – 33. Specific Gravity, 38/15.5 C, of Creosote Fractions 268
D 453 – 41. Tar Acids in Creosote and Creosote – Coal Tar Solutions 270
*D 88 – 56. Viscosity, Saybolt 410
D 347 – 33. Volume and Specific Gravity Correction Tables for Creosote and Coal Tar 273
D 370 – 58. Water in Creosote 276
D 96 – 58 T. Water and Sediment by Means of Centrifuge 279
D 1413 – 56 T. Wood Preservatives by Laboratory Soil-Block Cultures 283

Methods for Chemical Analysis of:

D 1326 – 56. Ammoniacal Copper Arsenite 308
D 1274 – 56. Pentachlorophenol 312
D 1035 – 50. Tanalith 314
D 199 – 50. Zinc Chloride 297
D 1033 – 50. Zinc Chloride, Chromated 301
D 1273 – 56. Zinc Chloride, Copperized Chromated 304

For Contents in Numeric Sequence, see p. ix.

Definitions of Terms Relating to:

PAGE
D 324 – 41. Timber Preservatives 318

General Testing Methods

Methods of:

*D 139 – 49. Float Test for Bituminous Materials 399
*D 158 – 54. Distillation of Gas Oil and Similar Distillate Fuel Oils 402
*D 287 – 55. Gravity, API, of Petroleum and Its Products, Hydrometer Method 407
*D 88 – 56. Saybolt Viscosity 410
E 4 – 57 T. Verification of Testing Machines 418
E 74 – 57. Verification of Calibration Devices for Verifying Testing Machines 424
E 83 – 57 T. Verification and Classification of Extensometers 430

APPENDICES

Officers of Committee D-7 and Its Subcommittees 441
Membership Application Blank 443

For Contents in Numeric Sequence, see p. ix.

CONTENTS IN NUMERIC SEQUENCE

ASTM STANDARDS[a] RELATING TO WOOD, WOOD-BASE MATERIALS, AND WOOD PRESERVATIVES

PAGE

*D 9 – 30. Def. of Terms Relating to Timber 164
D 25 – 58. Spec. for Round Timber Piles 219
D 38 – 33. Methods of Sampling and Testing Creosote 249
D 52 – 58 T. Spec. for Wood Paving Blocks for Exposed Platforms, Pavements, Driveways, and Interior Floors Exposed to Wet and Dry Conditions (Tentative) 224
*D 88 – 56. Method of Test for Saybolt Viscosity 410
*D 93 – 58 T. Method of Test for Flash Point by Pensky-Martens Closed Tester (Tentative) 260
D 96 – 58 T. Method of Test for Water and Sediment by Means of Centrifuge 279
*D 139 – 49. Method of Float Test for Bituminous Materials 399
*D 143 – 52. Methods of Testing Small Clear Specimens of Timber 1
*D 158 – 54. Method of Test for Distillation of Gas Oil and Similar Distillate Fuel Oils 402
D 168 – 30. Method of Test for Coke Residue of Creosote 252
*D 198 – 27. Methods of Static Tests of Timbers in Structural Sizes 100
D 199 – 50. Methods of Chemical Analysis of Zinc Chloride 297
*D 245 – 57 T. Methods for Establishing Structural Grades of Lumber 184
D 246 – 49. Method of Test for Distillation of Creosote 254
*D 287 – 55. Method of Test for API Gravity of Petroleum and Its Products (Hydrometer Method) 407
D 324 – 41. Def. of Terms Relating to Timber Preservatives 318
D 347 – 33. Volume and Specific Gravity Correction Tables for Creosote and Coal Tar 273
D 358 – 55. Spec. for Wood to be Used as Panels in Weathering Tests of Paints and Varnishes 236
D 367 – 49. Methods of Test for Benzene-Insoluble Matter in Creosote 263
D 368 – 33. Method of Test for Specific Gravity of Creosote 266
D 369 – 33. Method of Test for Specific Gravity, 38/15.5 C, of Creosote Fractions 268
D 370 – 58. Method of Test for Water in Creosote 276
D 390 – 53. Spec. for Creosote 239
D 391 – 53. Spec. for Creosote-Coal Tar Solution 241
D 432 – 50. Spec. for Zinc Chloride 243
D 453 – 41. Method of Test for Tar Acids in Creosote and Creosote-Coal Tar Solutions 270
*D 805 – 52. Methods of Testing Veneer, Plywood, and Other Glued Veneer Constructions 57
*D 1031 – 55. Spec. for Creosoted End-Grain Wood Block Flooring for Interior Use 227
D 1032 – 50. Spec. for Chromated Zinc Chloride 244
D 1033 – 50. Methods of Chemical Analysis of Chromated Zinc Chloride 301
D 1034 – 50. Spec. for Tanalith 248
D 1035 – 50. Methods of Chemical Analysis of Tanalith 314
D 1036 – 58. Methods of Static Tests of Wood Poles 116

---

* Approved as **American Standard** by the American Standards Association.

[a] Standards marked T are designated by the Society as Tentative to indicate either a new standard or an older one that may have been recently revised. There need be no distinction in their use from that of other standards of the Society.

PAGE
*D 1037 – 56 T. Methods of Test for Evaluating the Properties of Building Fiberboards 81
*D 1038 – 52. Def. of Terms Relating to Veneer and Plywood 169
D 1101 – 58. Method of Test for Integrity of Glue Joints in Laminated Wood Products for Exterior Service 136
D 1102 – 56. Method of Test for Ash in Wood 139
D 1103 – 55 T. Method of Test for Alpha-Cellulose in Wood 141
D 1104 – 56. Method of Test for Holocellulose in Wood 144
D 1105 – 56. Method for Preparation of Extractive-Free Wood 146
D 1106 – 56. Method of Test for Lignin in Wood 151
D 1107 – 56. Method of Test for Alcohol-Benzene Solubility of Wood 156
D 1108 – 56. Method of Test for Ether Solubility of Wood 158
D 1109 – 56. Method of Test for One Per Cent Caustic Soda Solubility of Wood (Tentative) 160
D 1110 – 56. Methods of Test for Water Solubility of Wood 162
*D 1165 – 52. Nomenclature of Domestic Hardwoods and Softwoods 175
D 1166 – 55 T. Method of Test for Methoxyl Groups in Wood and Related Materials (Tentative) 151
D 1271 – 56. Specs. for Copperized Chromated Zinc Chloride 245
D 1272 – 56. Specs. for Pentachlorophenol 247
D 1273 – 56. Methods for Chemical Analysis of Copperized Chromated Zinc Chloride 304
D 1274 – 56. Methods for Chemical Analysis of Pentachlorophenol 312
*D 1324 – 57 T. Spec. for Modified Wood 231
D 1325 – 56. Spec. for Ammoniacal Copper Arsenite 246
D 1326 – 56. Methods for Chemical Analysis of Ammoniacal Copper Arsenite. 308
D 1413 – 56 T. Method of Testing Wood Preservatives by Laboratory Soil-Block Cultures 283
D 1554 – 58 T. Def. of Terms Relating to Wood-Base Fiber and Particle Panel Materials 180
E 4 – 57 T. Methods of Verification of Testing Machines 418
E 69 – 50. Method of Test for Combustible Properties of Treated Wood by the Fire-Tube Apparatus 368
E 72 – 55. Methods of Conducting Strength Tests of Panels for Building Construction 321
E 73 – 52. Methods of Testing Truss Assemblies 351
E 74 – 57. Methods of Verification of Calibration Devices for Verifying Testing Machines 424
E 83 – 57 T. Method of Verification and Classification of Extensometers 430
E 84 – 50 T. Method of Fire Hazard Classification of Building Materials 390
E 90 – 55. Rec. Practice for Laboratory Measurement of Airborne-Sound Transmission Loss of Building Floors and Walls 356
*E 119 – 58. Methods of Fire Tests of Building Construction and Materials .. 374
E 136 – 58 T. Method of Test for Defining Noncombustibility of Building Materials 393
*E 152 – 58. Methods of Fire Tests of Door Assemblies 385
E 160 – 50. Method of Test for Combustible Properties of Treated Wood by the Crib Test 363

APPROVED AS
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ASA NO.: O4.1–1958
UDC 691.11:620.1

Standard Methods of

TESTING SMALL CLEAR SPECIMENS OF TIMBER[1]

ASTM Designation: D 143 – 52

ADOPTED, 1948; REVISED, 1949, 1950, 1952.[2]

Reapproved in 1958 Without Change.

This Standard of the American Society for Testing Materials is issued under the fixed designation D 143; the final number indicates the year of original adoption as standard or, in the case of revision, the year of last revision.

PART I. PRIMARY METHOD

Part I, Primary Method, is the basic procedure intended for the broadest possible use in evaluating the strength and related properties of wood in the form of small clear specimens. These methods afford satisfactory results, have been widely used, and extensive data based on their use have been obtained and published. Any departure in cross-section of specimens from the 2 by 2-in. size employed in the Primary Method introduces a variable that appreciably affects the results for certain properties, and thereby limits the full comparability desired for obtaining uniform results among different species. Only when relatively small trees, generally less than 12 in. in diameter, are available to produce the test specimens, and only when such trees because of crook, cross grain, knots, or other defects are of such quality that the longer specimens required in Part I, Primary Method cannot be obtained, should the procedures for Part II, Secondary Method be employed.

INTRODUCTION

The everyday use of timber for multitudinous purposes makes manifest a continual need of data on its mechanical properties. The great variety of species, the variability of the material, the continually changing conditions of supply, the many factors affecting test results, all combine to make the technique of testing wood unique in its complexity.

In the preparation of this procedure for testing small clear specimens, consideration was given both to the desirability of adopting methods which would yield results comparable to those already available and to the possibility of embodying such improvements as experience has shown desirable. In view of the many thousands of tests made under a single comprehensive plan by the U. S. Forest Service, the Forest Products Laboratories of Canada, and other similar organizations, the procedure naturally conforms closely to the methods used by these institutions. This procedure is the outgrowth of a study of both American and European experience and methods. Its general adoption will tend toward a world-wide unification of results, permitting an interchange and correlation of data, and will establish the basis for a cumulative body of fundamental information on the timber species of the world.

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[1] Under the standardization procedure of the Society, these methods are under the jurisdiction of the A.S.T.M Committee D-7 on Wood.

[2] Prior to their present adoption as standard, these methods were published as tentative from 1922 to 1927, being revised in 1924. They were adopted in 1927 and published as standard from 1927 to 1947. They were revised in 1947 and republished as tentative from 1947 to 1948.

These methods represent the entire procedure from selection of the trees to the manipulation of the test, thus controlling factors, such as the size and proportion of test specimens and rate of loading, that may influence results. No attempt has been made to cover methods of computation and analysis, as these questions may be considered independently at any time. Such sample data and computation sheets and cards have been incorporated, however, as were thought to be of assistance to the investigator in systematizing records.

Purpose of Tests

1. Tests on small clear specimens of wood are made to afford:

(*a*) Data for comparing the mechanical properties of various species.

(*b*) Data for the establishment of correct strength functions which, in conjunction with results of tests of timbers in structural sizes,[3] afford the basis for fixing allowable stresses.

(*c*) Data upon which to determine the influence on the mechanical properties of such factors as density, locality of growth, position in cross-section, height of timber in the tree, change of properties with seasoning, and change from sapwood to heartwood.

Kind of Tests

2. (*a*) The principal mechanical tests are static bending, compression parallel to grain, impact bending, toughness, compression perpendicular to grain, hardness, shear parallel to grain,[4] cleavage, and tension parallel to grain. The tension perpendicular to grain and the nail withdrawal tests also included are optional. These tests are made on both green and air-dry material as specified in these methods. In addition, methods for evaluating such physical properties as specific gravity, shrinkage in volume, radial shrinkage, and tangential shrinkage are presented.

(*b*) The procedures for collection and preparation of the material for testing and for the various tests appear in the following order:

	Sections
Collection of Material:	
Selection	3 to 7
Field Marking	8 to 12
Field Descriptions	13
Preparation for Shipment	14
Disposition at Destination:	
Storage of Logs at Destination	15
Photographing, Sawing, and Final Marking	16 to 18
Matching for Tests of Air-Dry Material	19 and 20
Disposition of Sticks	21 and 22
Order, Selection, and Number of Tests	23
Selection of Specimens	24 to 26
Number of Tests for Each Bolt	27 to 40
Photographs of Sticks	41
Control of Moisture Content and Temperature	42 and 43
Record of Heartwood and Sapwood	44
Static Bending	45 to 52
Compression Parallel to Grain	53 to 60
Impact Bending	61 to 70
Toughness	71 to 76
Compression Perpendicular to Grain	77 to 82
Hardness	83 to 87
Shear Parallel to Grain	88 to 92
Cleavage	93 to 97
Tension Parallel to Grain	98 to 102
Tension Perpendicular to Grain	103 to 107
Nail Withdrawal	108 to 113
Specific Gravity and Shrinkage in Volume	114 and 115
Radial and Tangential Shrinkage	116 to 121
Moisture Determination	122 to 125
Permissible Variations	126 to 128
Calibration	129

COLLECTION OF MATERIAL

Selection

Authentic Identification

3. The material shall be from trees selected in the forest by one qualified to identify the species and to select the trees. Whenever practicable this should be a member of the timber mechanics

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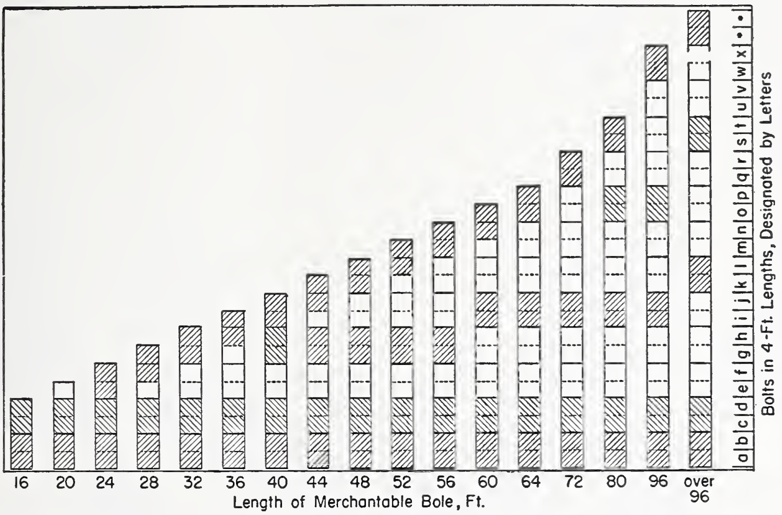
[3] See the Standard Methods of Static Tests of Timbers in Structural Sizes (A.S.T.M. Designation: D 198), p. 100.

[4] The test for shearing strength perpendicular to the grain (sometimes termed "vertical shear") is not included as one of the principal mechanical tests since in such a test the strength is limited by the shearing resistance parallel to the grain.

staff of the laboratory concerned, and where necessary, herbarium samples including leaves, fruit, twigs, and bark shall be obtained to ensure positive identification.

Selection and Number of Trees

4. For each species to be tested, at least five trees representative of the species shall be selected.


16
20
24
28
32
36
40
44
48
52
56
60
64
72
80
96
over 96
Length of Merchantable Bole, Ft.
a
b
c
d
e
f
g
h
i
j
k
l
m
n
o
p
q
r
s
t
u
v
w
x
•
Bolts in 4-Ft. Lengths, Designated by Letters

Letters a, b, c, etc. indicate 4-ft. units of the merchantable length, called bolts, and designate height in the tree.
*** Indicates bolts to be taken from the top of the merchantable length, to be lettered appropriately according to their actual height in the tree.**

FIG. 1.—Diagram Indicating Number and Position of Bolts to be Collected from Trees Having Boles of Various Merchantable Lengths, to Evaluate Effect of Height in Tree on Properties of the Wood.

Selection and Number of Bolts

5. The material of each species selected for test shall be representative of the merchantable bole of the tree. One method of selection which has been found satisfactory is as follows:

(*a*) From one tree of each group of five, select 8-ft. sections (each section representing two 4-ft. bolts) from various heights to afford information on the variation of properties with height in tree, as indicated in Fig. 1 and as follows:

Length of Merchantable Bolt, ft.	Bolts To Be Selected (for Explanation of Letter Designation of Bolts, See Section 9)
16	*a, b; c, d*
20	*a, b; c, d*
24	*a, b; c, d; e,*
28	*a, b; c, d; f, g*
32	*a, b; c, d; g, h*
36	*a, b; c, d; h, i*
40	*a, b; c, d; g, h; i, j*
44	*a, b; c, d; g, h; j, k*
48	*a, b; c, d; g, h; k, l*
52	*a, b; c, d; g, h; l, m*
56	*a, b; c, d; g, h; m, n*
60	*a, b; c, d; i, j; n, o*
64	*a, b; c, d; i, j; o, p*
72	*a, b; c, d; i, j; q, r*
80	*a, b; c, d; i, j; o, p; s, t*
96	*a, b; c, d; i, j; o, p; w, x*
Over 96	*a, b; c, d; k, l; s, t;* and last two bolts (each 4 ft in length) at top of merchantable length

(*b*) From the other trees called for in Section 4, take the 8-ft. section[5] (*c-d* bolts) next above the 8-ft. butt log.

Substitution of Flitches for Bolts

6. In cases where the logs or bolts are over 60 in. in diameter, a single flitch 6 in. in thickness, taken through the pith in a north and south direction and representing the full diameter of the log, may be substituted, in the same length, for the full log or bolt specified in Section 5.

Selection for Important Species

7. For important species of wide geographical distribution, test material

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[5] The 8-ft. lengths specified are intended to provide test material in sticks of this net length. It is recommended that the bolts or sections be cut in the woods to 9-ft. lengths, to allow for trimming, etc.

shall be selected from two or more localities or sites. The number of trees of a species selected from each site or locality shall conform to the requirements of Sections 4 and 5.

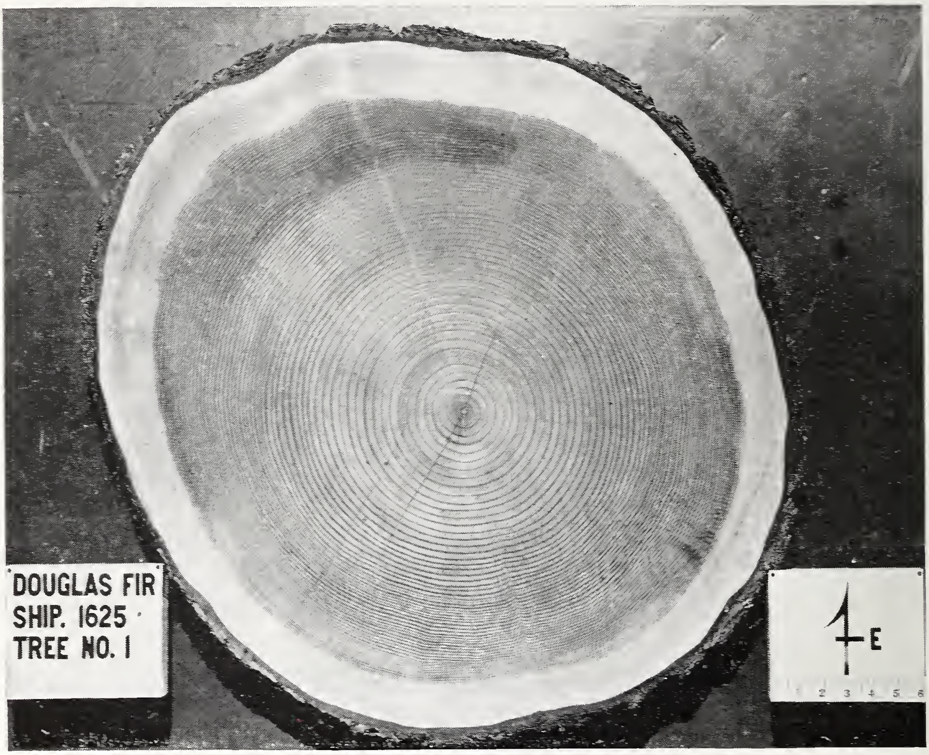

FIG. 2.—Section of Log Selected for Test Material.

Field Marking

Tree Designation

8. Each tree shall be given an arabic number, the numbering in any given shipment to be consecutive for trees of a given species.

Bolt Designation

9. Each 4 ft. of length of a tree or log shall be considered a "bolt." Bolts shall be designated by small letters, beginning with *a* for the 4-ft. section next above the stump. Bolt letters, therefore, indicate position with respect to height in tree.

Manner of Marking

10. The tree number and bolt designation shall be plainly marked upon each log selected by the collector. Thus the 16-ft. butt log of Tree No. 2 would be designated 2*abcd*. Steel dies are recommended for marking the butt end of the logs.

Indication of Cardinal Point

11. The north side of each log shall be indicated in some convenient manner.

Shipment Number

12. All material collected from a given locality and shipped at one time shall be given a shipment number or other designation.

Field Descriptions

Field Descriptions

13. (*a*) Complete field notes describing the material shall be fully and

carefully made by the collector. These notes shall, in general, supply data as outlined in Table I (at the end of the Appendix).

(*b*) Photographs of the standing trees selected should be taken, when practicable.

Preparation For Shipment

Preparation for Shipment

14. (*a*) The bark will be left on each log, and care shall be taken to keep the bark intact. The ends of the logs shall be carefully painted to retard or prevent end drying and end checking.

(*b*) Record shall be made of the shipment routing, bill of lading, kind of shipment, date of shipment, and condition of material when shipped.

(*c*) Record shall also be made of date of receipt of shipment at destination, its condition, and method of storage.

DISPOSITION AT DESTINATION

Storage of Logs at Destination

Storage of Logs

15. Material shall not be kept in the bolt or log form long enough to permit damage by checks, decay, stains, or insect attack. The logs shall be piled on skids, free from contact with the soil, and shall not be stored where subjected to artificial heat. In addition they should preferably be protected from the sun and, when necessary, sprinkled regularly with water to prevent drying. As an alternative to piling on skids, the logs may be stored in water prior to testing.

Photographing, Sawing, and Final Marking

Note.—In sawing, marking, and selecting test sticks, the aim should be to obtain specimens representative of the material collected. The procedure described herein is one that has been found satisfactory for most species.

Photographing Ends of Bolts

16. The top end of each *d* or *c-d* bolt shall be photographed. It is suggested that a rule be placed on the log so as to indicate the scale of the photograph and that the cardinal points be indicated on the cross-section. Figure 2 shows a photograph of this kind.

Sawing of Bolts

17. (*a*) All bolts shall be marked on the top end into $2\frac{1}{2}$ by $2\frac{1}{2}$-in. squares as shown in Fig. 3, and sawed into nominal $2\frac{1}{2}$ by $2\frac{1}{2}$-in. sticks. The letters *N*, *E*, *S*, and *W* indicate the cardinal points.

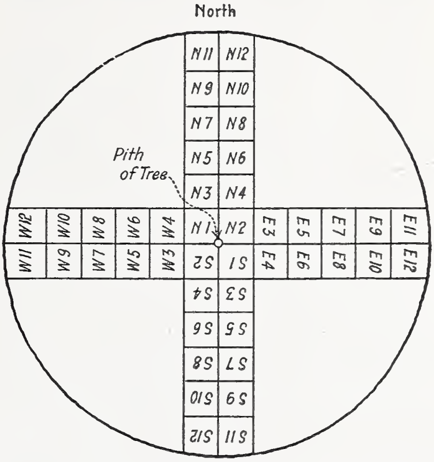

Fig. 3.—Sketch Showing Method of Cutting Up the Bolt and Marking the Sticks.

(*b*) When flitches are substituted for bolts (Section 6), the same general marking and numbering scheme of Paragraph (*a*) shall be followed in so far as it is applicable.

Marking of Test Sticks

18. All test sticks shall bear the shipment number, the tree number, stick number, and bolt designation, to be known respectively as Shipment No., Piece No., Stick No., and mark. Thus, 400-1-*N*4*d* represents Stick *N*4 of Bolt d, Tree 1, Shipment 400.

Matching for Test of Air-Dry Material

Composite Bolts

19. (*a*) The collection of the material (Section 5) has been arranged to provide for tests of both green and air-dry specimens that are closely matched by selection from adjacent parts of the same tree. The 8-ft. long bolts, after being marked in accordance with Section 17 (*a*), shall be sawed into 2½ by 2½-in. by 8-ft. sticks, and numbered and lettered in accordance with Section 18. Each 2½ by 2½-in. by 8-ft. stick shall then be cut into two 4-ft. pieces, making sure that each part carries the proper designation and bolt letter.

(*b*) Part of the 2½ by 2½-in. by 4-ft. sticks from each 8-ft. bolt are to provide specimens to be tested green (unseasoned) and the other part are to provide specimens to be air-dried and tested. To afford matching, the 4-ft. sticks of one bolt shall be interchanged with the 4-ft. sticks of the next adjacent bolt from the same tree to form two composite bolts, each being complete and being made of equal portions of the adjacent 4-ft. bolts. The sticks from one of these composite bolts shall be tested green and those from the other shall be tested after air-drying. Thus, the sticks of each composite bolt shall be regarded as if they were from the same bolt.

(*c*) The above procedure provides for end to end matching (end matching) of sticks to be tested air-dry with those to be tested green, which is to be preferred when practicable. If, because of the nature of the material, end matching is not practicable, side matching may be used.

Schedule for Forming Composite Bolts

20. (*a*) The division of sticks into composite bolts, part to be tested green and part to be air-dried and tested, shall be made according to the following schedule, in which the numbers refer to stick numbers:

SELECTION OF STICKS FROM *a* AND *b* BOLTS

Composite Bolt to be Tested Green:						
Bolt *a*	1		4, 5		8, 9	
Bolt *b*		2, 3		6, 7		10, etc.
Composite Bolt to be Air-Dried and Tested:						
Bolt *a*		2, 3		6, 7		10, etc.
Bolt *b*	1		4, 5		8, 9	

SELECTION OF STICKS FROM *c* AND *d* BOLTS

Composite Bolt to be Tested Green:						
Bolt *c*	1		4, 5		8, 9	
Bolt *d*		2, 3		6, 7		10, etc.
Composite Bolt to be Air-Dried and Tested:						
Bolt *c*		2, 3		6, 7		10, etc.
Bolt *d*	1		4, 5		8, 9	

SELECTION OF STICKS FROM *e* AND *f* BOLTS

Composite Bolt to be Tested Green:						
Bolt *e*	1		4, 5		8, 9	
Bolt *f*		2, 3		6, 7		10, etc.
Composite Bolt to be Air-Dried and Tested:						
Bolt *e*		2, 3		6, 7		10, etc.
Bolt *f*	1		4, 5		8, 9	

(*b*) The selection of sticks from other 8-ft. bolts of the tree to form the composite bolts to be tested green and to be air-dried and tested shall be made in accordance with the system as indicated in Paragraph (*a*).

(*c*) As an example of composite bolts, assume that the cross section, Fig. 3, represents the end of an 8-ft. section comprising the *c* and *d* bolts.

The following sticks are selected for the composite bolt to be tested green: *N*1*c*, *N*2*d*, *N*3*d*, *N*4*c*, *N*5*c* *N*6*d*, *N*7*d*, *N*8*c*, *N*9*c*, *N*10*d*, *N*11*d*, *N*12*c*; *E*3*d*, *E*4*c*, *E*5*c*, *E*6*d*, *E*7*d*, *E*8*c*, *E*9*c*, *E*10*d*, *E*11*d*, *E*12*c*; *S*1*c*, *S*2*d*, *S*3*d*, *S*4*c*, *S*5*c*, *S*6*d*, *S*7*d*, *S*8*c*, *S*9*c*, *S*10*d*, *S*11*d*, *S*12*c*; *W*3*d*, *W*4*c*, *W*5*c*, *W*6*d*, *W*7*d*, *W*8*c*, *W*9*c*, *W*10*d*, *W*11*d*, *W*12*c*.

The following sticks are selected for the composite bolt to be air-dried and tested: *N*1*d*, *N*2*c*, *N*3*c*, *N*4*d*, *N*5*d*, *N*6*c*, *N*7*c*, *N*8*d*, *N*9*d*, *N*10*c*, *N*11*c*, *N*12*d*; *E*3*c*, *E*4*d*, *E*5*d*, *E*6*c*, *E*7*c*, *E*8*d*, *E*9*d*, *E*10*c*, *E*11*c*, *E*12*d*; *S*1*d*, *S*2*c*, *S*3*c*, *S*4*d*, *S*5*d*, *S*6*c*, *S*7*c*, *S*8*d*, *S*9*d*, *S*10*c*, *S*11*c*, *S*12*d*; *W*3*c*, *W*4*d*, *W*5*d*, *W*6*c*, *W*7*c*, *W*8*d*, *W*9*d*, *W*10*c*, *W*11*c*, *W*12*d*.

Disposition of Sticks

Green Material

21. The sticks (2½ by 2½ in. by 4 ft.) to be tested green shall be kept in an unseasoned condition, while awaiting

preparation for test, by being stored in a framed pit or other suitable container, where they shall be close piled and covered with damp sawdust, or in some other suitable manner. As material is required for test, it shall be removed from this pit or container, surfaced on all four sides to 2 by 2 in. (5 by 5 cm) in cross section, sawed to test size, and kept covered with a damp cloth in a tightly closed container at a temperature of 20 ± 3 C (68 ± 6 F) (See Note, Section 22 (*e*)) until the time of test. Care shall be taken to avoid as much as possible the storage of green material in any form. Sticks to be tested in a green condition usually should not be sawed from the log form in quantities greater than is required to meet the testing demands for from a few days to not more than two weeks, depending on the prevailing conditions.

Air-Dry Material

22. (*a*) The ends of the sticks to be air-dried ($2\frac{1}{2}$ by $2\frac{1}{2}$ in. by 4 ft.) shall be dipped in melted paraffin or other substance suitable to retard checking. The material shall be piled so as to have a space of at least $\frac{1}{2}$ in. on each side of each stick to permit circulation of air. The material shall be stored in a place allowing free access of air, but protected from sunshine, rain, snow, and moisture from the ground. The sticks in drying shall not be subjected to artificial heat.

(*b*) All of the sticks from each composite bolt to be air-dried shall be weighed when stored and at sufficiently frequent intervals thereafter to get accurate data on the progress of seasoning. No material shall be considered thoroughly air-dried and properly conditioned for testing until practically constant weight has been reached. (Wood absorbs and gives off moisture with changing atmospheric conditions; consequently it never comes to absolutely constant weight.)

(*c*) When the material has reached equilibrium, moisture sections approximately 1 in. (2.5 cm) in length shall be taken from about 10 per cent of the sticks to determine the actual moisture content. These moisture specimens shall be cut not less than 1 ft. (30 cm) from the ends of the sticks, and in such a way as to prevent any appreciable loss of material for testing. When conditioned to approximately 12 per cent moisture content, the material shall be surfaced on four sides to 2 by 2 in. (5 by 5 cm) in cross-section and tested.

(*d*) When adequate facilities are available, the sticks may be kiln-dried instead of air-dried in order to reduce the drying time. The preparation of the sticks and procedures followed shall be similar to those used in air-drying, and the drying shall be continued until the sticks have a moisture content of approximately 12 per cent. The kilns shall be operated in a manner and at such temperatures as are in accordance with best practices for drying the species in question without injury to the strength, and the drying shall be done to avoid kiln-drying defects such as "casehardening", "honeycombing", or "collapse". A record of operating conditions of the kiln shall be kept for the entire run and shall include humidity conditions and temperatures at the hottest part of the kiln. In general, the maximum kiln temperature shall not exceed 130 F (54 C), but the exact permissible limits such as are suitable for kiln-drying airplane stock without injury depend on the species.

(*e*) The seasoned sticks, whether kiln-dried or air-dried, preferably should be stored in a room having controlled temperature and humidity (at 20 ± 3 C (68 ± 6 F) and 65 ± 1 per cent relative humidity) before test to reduce the moisture gradient within the material, and to bring the material into equilibrium, which will be approximately 12 per cent moisture content for most species.

NOTE.—In following the recommendation that the temperature be controlled at 20 ± 3 C (68 ± 6 F), it should be understood that it is desirable to maintain the temperature as nearly constant as possible at some temperature within this range.

ORDER, SELECTION, AND NUMBER OF TESTS

Order of Tests

Order of Tests

23. The order of tests in all cases shall be such as to eliminate as far as possible from the comparisons the effect of changes in the specimen due to such factors as storage and weather conditions.

Selection of Specimens

Preference in Selecting Specimens

24. In case the material from a given bolt should be insufficient to furnish all the test specimens hereinafter required (logs or bolts less than 24 in. in diameter), additional bolts may be selected. If additional material is not available, the preferential order of mechanical tests to be used in selecting specimens shall be as follows: Static bending, compression parallel to grain, impact bending, toughness, compression perpendicular to grain, hardness, shear parallel to grain, cleavage, tension parallel to grain, tension perpendicular to grain, and nail withdrawal.

Test Pieces from Bending Specimens After Failure

25. In some instances where the sticks do not provide sufficient material for all the tests, certain test specimens may be taken from the uninjured portion of the static and impact bending specimens remaining after test, provided proper care is used in the selection.

Quality of Test Material

26. Only clear straight-grained material, free of decay and other defects, shall be used for the tests. However, small knots and other similar defects may be permitted in such specimens as static bending when their location is such that it is certain they will not in any way influence the failure or otherwise affect the strength of the specimen.

Number of Tests for Each Bolt

Static Bending

27. One static bending specimen shall be taken from each pair of sticks. A pair consists of two adjacent sticks equidistant from the pith, as *W*3 and *W*4, Fig. 3. In the composite bolts tested to afford a comparison of the strength of green and air-dry material, the pair of sticks shall be constituted as above, except that the sticks in this case will be from different bolts. Thus, *W3d* and *W*4*c* constitute one pair of sticks to be tested green, and *W*3*c* and *W*4*d* the corresponding pair to be tested air-dry (Section 20).

Compression Parallel to Grain

28. One compression-parallel-to-grain specimen shall be taken from each stick. Load-compression curves shall preferably be taken on all of the specimens.

Impact Bending

29. Eight impact-bending specimens shall be taken from each bolt, selection being made from the sticks remaining after obtaining the static bending tests. Two of the specimens shall be selected from near the pith, two from near the periphery, and four that are representative of the cross-section.

Toughness

30. Two toughness specimens shall be selected from the uninjured portion or end of each impact bending specimen or companion static bending specimen, making a total of 32 toughness specimens for each bolt. One from each group of two specimens from the same stick shall be tested with the load applied radially and the other tested with the load applied tangentially.

Compression Perpendicular to Grain

31. One compression-perpendicular-to-grain specimen shall be taken from each of 50 per cent of the sticks selected for static bending.

Hardness

32. One hardness specimen shall be taken from each of the other 50 per cent of the static-bending sticks.

Shear Parallel to Grain

33. Twelve shear-parallel-to-grain specimens shall be selected from the unused portion or ends of six sticks from which bending specimens have been selected. Two specimens shall be taken from near the pith, two from near the periphery, and eight that are representative of the average growth of the cross-section of the bolt. These twelve specimens shall be selected in pairs from the six sticks. One of each pair of specimens from the same stick shall be tested in radial shear (surface of failure radial) and the other in tangential shear (surface of failure tangential).

Cleavage Perpendicular to Grain

34. Twelve cleavage specimens shall be selected from six sticks in a manner similar to that for shear (Section 33). One of each pair of specimens from the same stick shall be tested in radial cleavage (surface of failure radial) and the other in tangential cleavage (surface of failure tangential).

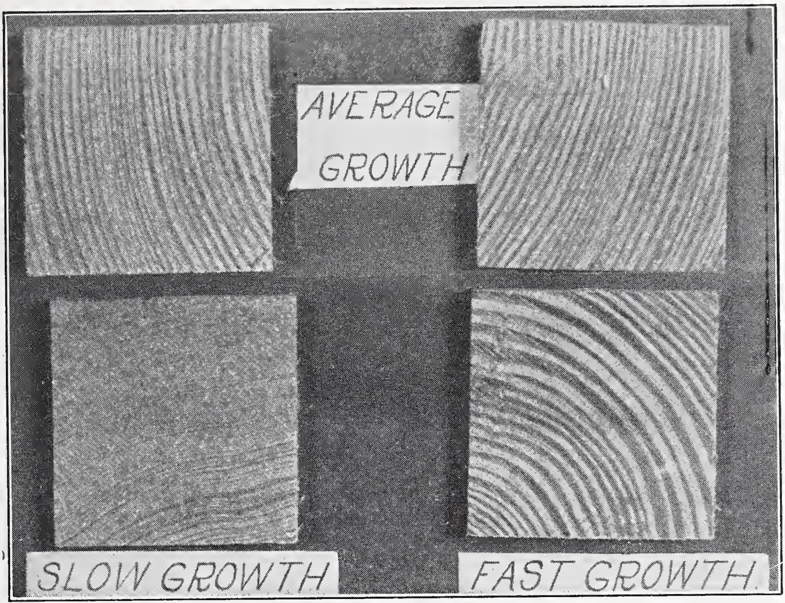

FIG. 4.—Cross-Sections of Bending Specimens Showing Different Rates of Growth of Longleaf Pine (2 by 2-in. Specimens).

Tension Parallel to Grain

35. Six tension-parallel-to-grain specimens shall be chosen of which one shall be selected from near the pith, one from near the periphery, and four that are representative of the cross-section.

Tension Perpendicular to Grain

36. Twelve tension-perpendicular-to-grain specimens shall be selected from six sticks in a manner similar to that for shear (Section 33). One of each pair of

specimens from the same stick shall be tested in radial tension (surface of failure radial) and the other in tangential tension (surface of failure tangential).

Nail Withdrawal

37. Twelve nail withdrawal specimens shall be selected from the unused portion or ends of 12 of the sticks from which bending or tension-parallel-to-grain specimens have been selected or, if necessary, from the uninjured portion of specimens from other tests. Six nail withdrawal specimens shall be tested in the green and six in the air-dry condition. The specimens for testing in both the green and the air-dry conditions shall be selected so as to give one from near the pith, one from near the periphery, and four that are representative of the average growth of the cross-section of the bolt.

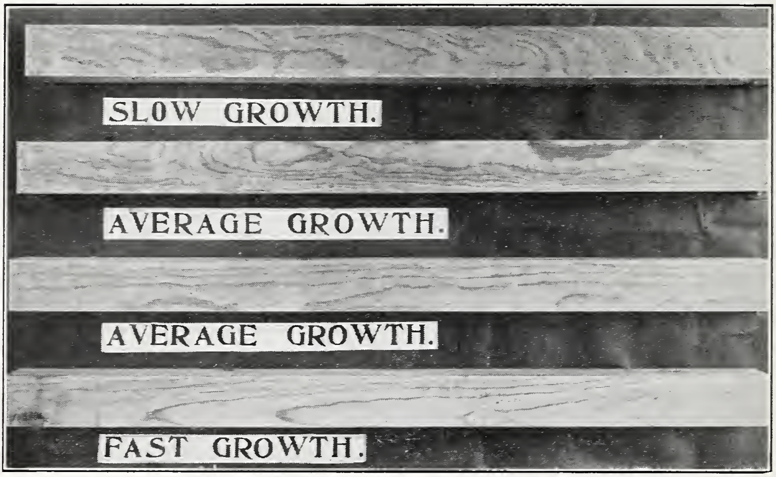

Fig. 5.—Tangential Surfaces of Bending Specimens of Different Rates of Growth of Jeffrey Pine (2 by 2 by 30-in. Specimens).

Specific Gravity and Shrinkage in Volume

38. Six specific gravity and shrinkage-in-volume specimens shall be selected from the unused portion of bending or tension-parallel-to-grain sticks, selected so as to give one from near the pith, one from near the periphery, and four that are representative of the average growth of the cross-section of the bolt. These specimens shall be selected only from the sticks to be tested in a green condition.

Radial Shrinkage

39. Four radial shrinkage specimens shall be obtained from each *d* bolt, and where possible from the upper bolt of each pair of bolts selected at other heights in the tree. They shall be cut from the "sectors" or "quadrants" remaining after sawing (Fig. 3) or from disks cut from near the end of the bolt. When a disk is used, care must be taken to see that it is green and has not been affected by shrinking and checking which is common near the end of the bolt. The specimens shall not be surfaced. Radial shrinkage specimens shall be cut with their greatest dimension in the radial direction. Two shall be taken from the heartwood and the other two from near the periphery. When possible, two specimens shall consist entirely of sapwood.

Tangential Shrinkage

40. Four tangential shrinkage specimens shall be obtained from each *d* bolt, and where possible from the upper bolt

of each pair of bolts selected at other heights in the tree. They shall be selected at the same time and in a manner similar to radial-shrinkage specimens (Section 39), except that the greatest dimension shall be in a tangential direction. The specimens shall not be surfaced. Two shall be taken from the heartwood; the other two shall be taken from near the periphery and when possible shall consist entirely of sapwood. The heartwood and the sapwood specimens shall be taken adjacent to the respective specimens selected for radial shrinkage.

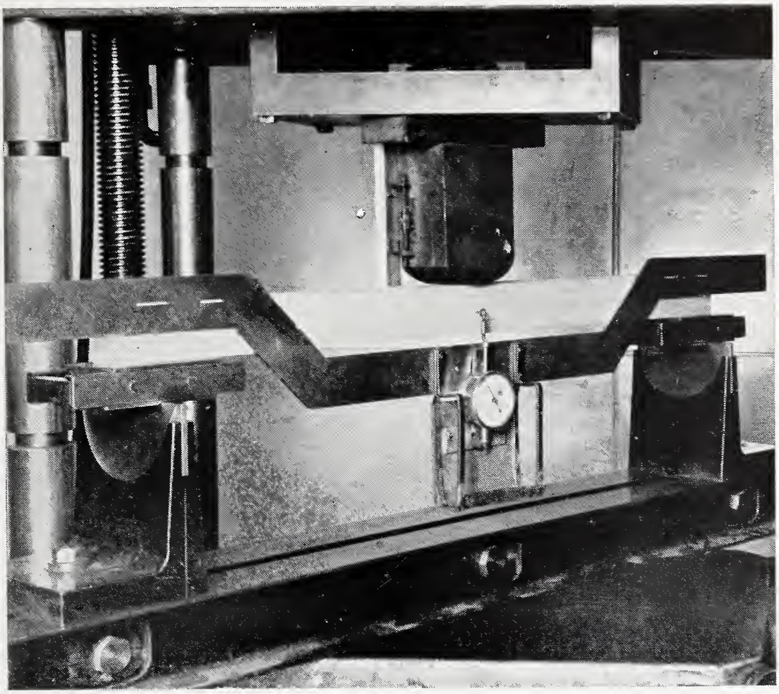

FIG. 6.—Static Bending Test Assembly Showing Method of Load Application, Specimen Supported on Rollers and Laterally Adjustable Knife Edges, and Method of Measuring Deflection at Neutral Axis by Means of Yoke and Dial Attachment. Adjustable Scale Mounted on Loading Head is Used to Measure Increments of Deformation Beyond the Dial Capacity.

PHOTOGRAPHS OF STICKS

Sticks to be Photographed

41. Four of the bending sticks from each species shall be selected for photographing, as follows: two average growth, one fast growth, and one slow growth. These sticks shall be photographed in cross-section and on the radial and tangential surfaces. Figure 4 is a typical photograph of the cross-section of test specimens and Fig. 5 of the tangential surface of bending specimens.

CONTROL OF MOISTURE CONTENT AND TEMPERATURE

NOTE.—In recognition of the significant influence of temperature and humidity on the strength of wood, it is highly desirable that these factors be controlled to ensure comparable test results.

Control of Moisture Content

42. As prescribed in Section 22, sticks for test in the air-dry condition shall be brought practically to constant weight before test. Should any changes in moisture content occur during final preparation of specimens, the specimens

shall be reconditioned before test to constant weight under conditions as prescribed in Section 22 (*e*). Tests shall then be carried out in such manner that large changes in moisture content will not occur. To prevent such changes, it is desirable that the testing room and rooms for preparation of test specimens have some means of humidity control.

Control of Temperature

43. Independent of the effect on strength of the moisture content of the test specimens as influenced by temperature, is the significant effect of temperature itself on the mechanical properties. The specimens when tested shall be at a temperature of 20 ± 3 C (68 ± 6 F) (See Note, Section 22 (*e*)) . The temperature at time of test shall in all instances be recorded as a specific part of the test record.

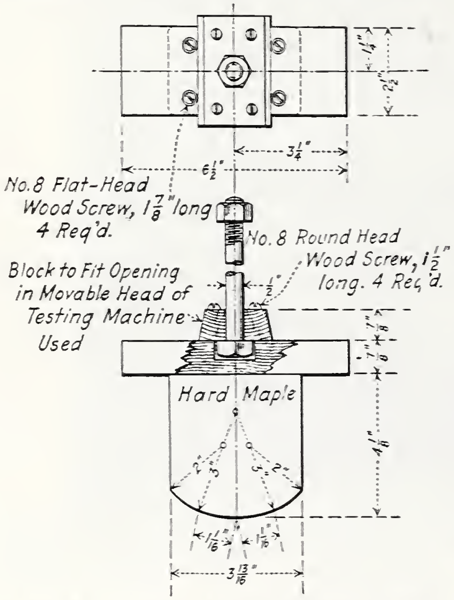

FIG. 7.—Details of Bearing Block for Static Bending Tests.

RECORD OF HEARTWOOD AND SAPWOOD

Proportion of Sapwood

44. The estimated proportion of sapwood present shall be recorded for each test specimen.

STATIC BENDING

Size of Specimens

45. The static bending tests shall be made on 2 by 2 by 30-in. (5 by 5 by 76-cm) specimens. The actual height and width at the center and the length shall be measured (Section 127).

Loading Span and Supports

46. Center loading and a span length of 28 in. (70 cm) shall be used. Both supporting knife edges shall be provided with bearing plates and rollers of such thickness that the distance from the point of support to the central plane is not greater than the depth of the specimen (Fig. 6). The knife edges shall be adjustable laterally to permit adjustment for slight twist or warp in the specimen.[6] Alternatively, the method of supporting the specimen in trunnion-type supports which are free to move in a horizontal direction may be employed.

Bearing Block

47. A bearing block of the form and size of that shown in Fig. 7 shall be used for applying the load.

Placement of Growth Rings

48. The specimen shall be placed so that the load will be applied through the bearing block to the tangential (flat-sawed) surface nearest the pith.

Speed of Testing

49. The load shall be applied continuously throughout the test at a rate of motion of the movable crosshead of 0.10 in. (2.5 mm) per min. (Section 128).

Load-Deflection Curves

50. (*a*) Load-deflection curves shall

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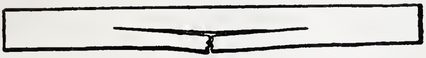
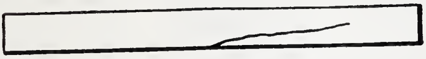
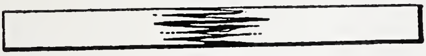
[6] Details of laterally adjustable supports may be found in Fig. 4 of the Standard Methods of Testing Veneer, Plywood, and Other Glued Veneer Constructions (A.S.T.M. Designation: D 805), p. 57.

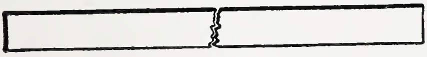
be taken to or beyond the maximum load for all static bending tests. In at least one third of the tests, the curves shall be continued to a 6-in. (15 cm) deflection, or until the specimen fails to support a load of 200 lb. (90 kg).

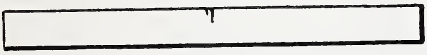
(*b*) Deflections of the neutral plane at the center of the length shall be taken with respect to points in the neutral plane above the supports.

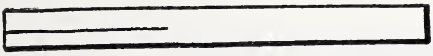

(*a*) Simple Tension.
(Side View)


(*b*) Cross-Grain Tension.*
(Side View)


(*c*) Splintering Tension.
(View of Tension Surface)


(*d*) Brash Tension.
(View of Tension Surface)


(*e*) Compression.
(Side View)


(*f*) Horizontal Shear.
(Side View)

* The term "cross grain" shall be considered to include all deviations of grain from the direction of the longitudinal axis or longitudinal edges of the specimen. It should be noted that spiral grain may be present even to a serious extent without being evident from a casual observation.

The presence of cross grain having a slope that deviates more than 1 in 20 from the longitudinal edges of the specimen shall be cause for culling the test.

Fig. 8.—Types of Failures in Static Bending.

(*c*) Within the proportional limit, deflection readings shall be taken to 0.001 (0.02 mm) in. After the proportional limit is reached, less refinement is necessary in observing deflections, but it is convenient to read them by means of the dial gage (Fig. 6) until it reaches the limit of its capacity, normally approximately 1 in. (2.5 cm) Where deflections beyond 1 in. (2.5 cm) are encountered, the deflections may be measured by means of the scale mounted on the loading head (Fig. 6) and a wire mounted at the neutral axis of the specimen on the side opposite the yoke. Deflections are read to the nearest 0.01 in. (0.2 mm) at 0.10 in. (2.5 mm) intervals and also after abrupt changes in load.

(*d*) The load and deflection of first failure, the maximum load, and points of sudden change shall be read and shown on the curve sheet[7] although they may not occur at one of the regular load or deflection increments.

Description of Static Bending Failures

51. Static bending (flexural) failures shall be classified according to the appearance of the fractured surface and the manner in which the failure develops (Fig. 8). The fractured surfaces may be roughly divided into "brash" and "fibrous", the term "brash" indicating abrupt failure and the term "fibrous" indicating a fracture showing splinters.

Weight and Moisture Content

52. The specimen shall be weighed immediately before test, and after test a moisture section approximately 1 in. (2.5 cm) in length shall be cut near the failure (Section 126).

COMPRESSION PARALLEL TO GRAIN

Size of Specimens

53. The compression-parallel-to-grain tests shall be made on 2 by 2 by 8-in. (5 by 5 by 20-cm) specimens. The actual cross-section dimensions and the length shall be measured (Section 127).

End Surfaces Parallel

54. Special care shall be used in preparing the compression-parallel-to-grain test specimens to ensure that the end grain surfaces will be parallel to each

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[7] See Fig. 31 of the Appendix for a sample static bending data sheet form.

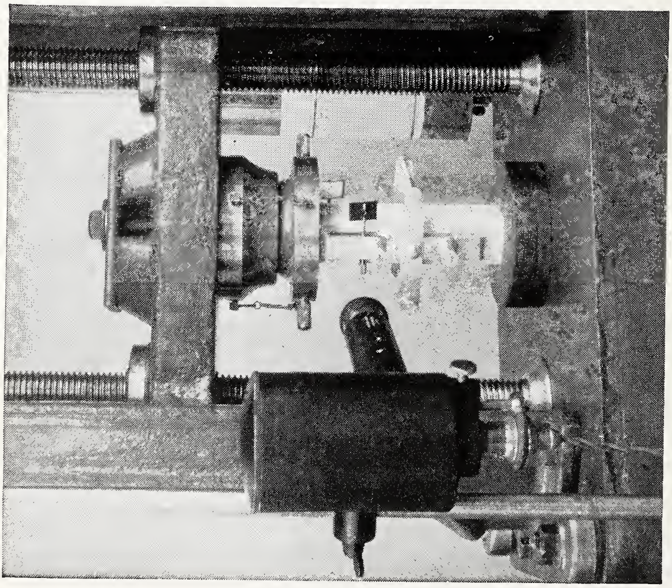


FIG. 9.—Compression Parallel-to-Grain Test Assembly Showing Method of Measuring Deformations by Means of a Roller-Type Compressometer.

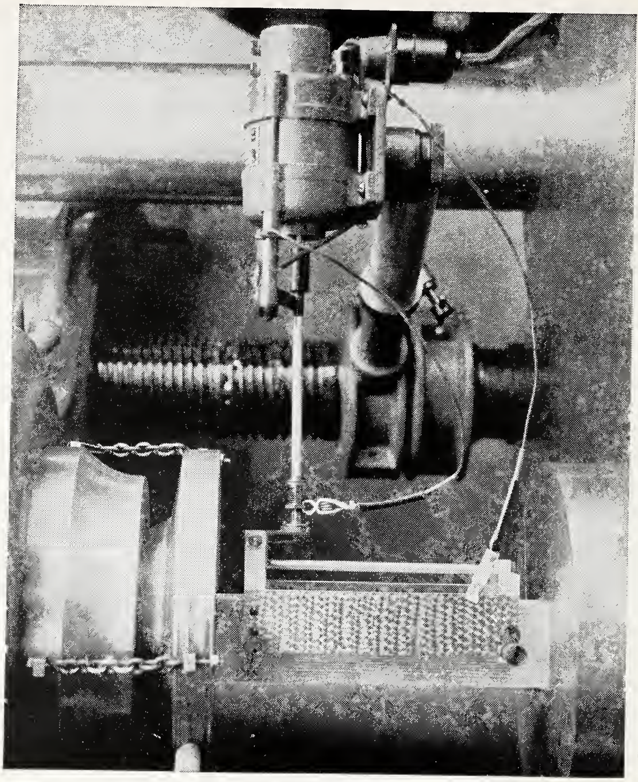


FIG. 10.—Compression-Parallel-to-Grain Test Assembly Using an Automatic Autographic Type of Compressometer to Measure Deformations. The Wire in the Lower Right-Hand Corner Connects the Compressometer with the Recording Unit.

other and at right angles to the longitudinal axis. If deemed necessary, at least one platen of the testing machine shall be equipped with a spherical bearing to obtain uniform distribution of load over the ends of the specimen.

Speed of Testing

55. The load shall be applied continuously throughout the test at a rate of motion of the movable crosshead of 0.003 in. per inch (cm per cm) of specimen length per min. (Section 128).

Load-Compression Curves

56. (*a*) Load-compression curves shall be taken over a central gage length not exceeding 6 in. (15 cm) and preferably on all of the specimens. Load-compression readings shall be continued until the proportional limit is well passed, as indicated by the curve.[8]

(*b*) Deformations shall be read to 0.0001 in. (0.002 mm).

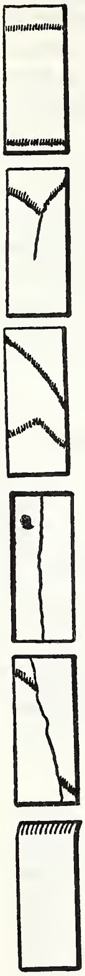
(*c*) Figs. 9 and 10 illustrate two types of compressometers that have been found satisfactory for wood testing.

Position of Test Failures

57. In order to obtain satisfactory and uniform results, it is necessary that the failures be made to develop in the body of the specimen. With specimens of uniform cross-section, this result can best be obtained when the ends are at a very slightly lower moisture content than the body. With green material it will usually suffice to close-pile the specimens, cover the body with a damp or wet cloth, and expose the ends for a short time. For air-dry material, it may sometimes be advisable to pile the specimens in a similar manner and place them in a desiccator should the failures in test indicate that a slight end-drying is necessary.

Description of Compression Failures

58. Compression failures shall be classified according to the appearance of the fractured surface (Fig. 11). In case two or more kinds of failures develop, all shall be described in the order of their occurrence; thus, shearing followed by brooming. The failure shall also be sketched in its proper position on the data sheet.



Crushing
This term shall be used when the plane of rupture is approximately horizontal.

Wedge Split
The direction of the split, that is whether radial or tangential, shall be noted.

Shearing
This term shall be used when the plane rupture makes an angle of more than 45 deg. with the top of the specimen.

Splitting
This type of failure usually occurs in specimens having internal defects prior to test and shall be the basis for culling the specimen.

Compression and Shearing Parallel to Grain
This failure usually occurs in cross-grained pieces and shall be the basis for culling the specimen.

Brooming or End-Rolling
This type of failure is usually associated with either an excess moisture content at the ends of the specimen, improper cutting of the specimen, or both. This is not an acceptable type of failure and usually is associated with a reduced load. Consideration should be given to remedial conditions when this type of failure is observed.

FIG. 11.—Types of Failures in Compression.

Weight and Moisture Content

59. The specimen shall be weighed immediately before test, and after test a moisture section approximately 1 in. (2.5 cm) in length shall be cut from the body near the failure (Section 126).

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[8] See Fig. 32 of the Appendix for a sample compression-parallel-to-grain data sheet form.

a radius of $\frac{3}{4}$ in. (18 mm) shall be used in applying the load.

Apparatus and Procedure

74. The tests shall be made in a Forest Products Laboratory type toughness machine (Fig. 13). The machine shall be adjusted before test so that the pendulum hangs truly vertical and shall be adjusted to compensate for friction. The cable shall be adjusted so that the load is applied to the specimen when the pendulum swings to 15 deg. from the vertical so as to produce complete failure by the time the downward swing is completed. The weight position and initial angle (30, 45, or 60 deg.) of the pendulum shall be chosen so that complete failure of the specimen is obtained on one drop. Most satisfactory results are obtained when the difference between the initial and final angle is at least 10 deg.

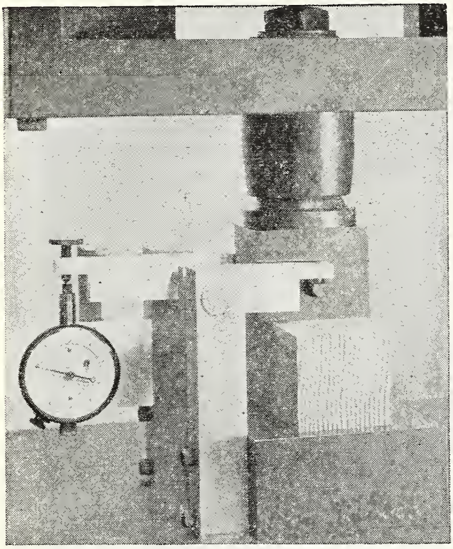

FIG. 14.—Compression-Perpendicular-to-Grain Test Assembly Showing Method of Load Application and Measurement of Deformation by Means of Averaging-Type Compressometer.

Calculation

75. The initial and final angle shall be read to the nearest 0.1 deg. by means of the vernier (Fig. 13) attached to the machine.[11] The toughness shall then be calculated as follows:

$$T = wL\,(\cos A_2 - \cos A_1)$$

where:

T = toughness (work per specimen), in inch-pounds (cm-kg),

w = weight of pendulum, in pounds (kg),

L = distance from center of the supporting axis to center of gravity of the pendulum, in inches (cm),

A_1 = initial angle (Note), in degrees, and

A_2 = final angle the pendulum makes with the vertical after failure of the test specimen, in degrees.

NOTE—Since friction is compensated for in the machine adjustment, the initial angle may be regarded as exactly 30, 45, or 60 deg., as the case may be.

Weight and Moisture Content

76. The specimen shall be weighed immediately before test, and after test a moisture section approximately 2 in. (5 cm) in length shall be cut from the body near the failure (Section 126).

COMPRESSION PERPENDICULAR TO GRAIN

Size of Specimens

77. The compression-perpendicular-to-grain tests shall be made on 2 by 2 by 6-in. (5 by 5 by 15-cm) specimens. The actual height, width, and length shall be measured (Section 127).

Loading

78. The load shall be applied through a metal bearing plate 2 in. (5 cm) in width, placed across the upper surface of the specimen at equal distances from the

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[11] See Fig. 36 of the Appendix for a sample data and computation sheet for the toughness test.

ends and at right angles to the length (Fig. 14).

Placement of Growth Rings

79. The specimens shall be placed so that the load will be applied through the bearing plate to a radial (quarter-sawed) surface.

Speed of Testing

80. The load shall be applied continuously throughout the test at a rate of motion of the movable crosshead of 0.012 in. (0.3 mm) per min. (Section 128).

Load-Compression Curves

81. (*a*) Load - compression curves[12] shall be taken for all specimens up to 0.1-in. (2.5 mm) compression, after which the test will be discontinued. Compression shall be measured between the loading surfaces.

(*b*) Deflection readings shall be taken to 0.0001 in. (0.002 mm).

Weight and Moisture Content

82. The specimen shall be weighed immediately before test, and after test a moisture section approximately 1 in. (2.5 cm) in length shall be cut adjacent to the part under load (Section 126).

HARDNESS

Size of Specimens

83. The hardness tests shall be made on 2 by 2 by 6-in. (5 by 5 by 15-cm) specimens. The actual cross-section dimensions and length shall be measured (Section 127).

Procedure

84. The modified ball test with a "ball" 0.444 in. (1.13 cm) in diameter shall be used for determining hardness (Fig. 15). The load at which the "ball" has penetrated to one half its diameter, as determined by an electric circuit indicator or by the tightening of the collar against the specimen, shall be recorded.

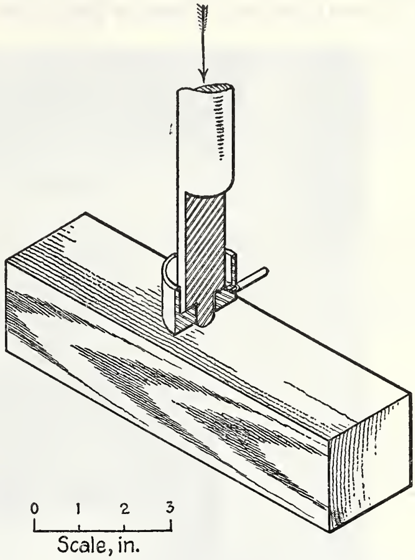

FIG. 15.—Diagrammatic Sketch of Method of Conducting Hardness Test.

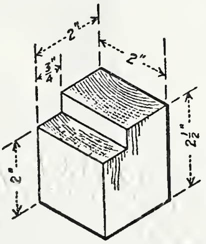

FIG. 16.—Shear-Parallel-to-Grain Test Specimen.

Number of Penetrations

85. Two penetrations shall be made on a tangential surface, two on a radial surface, and one on each end. The choice between the two radial and between the two tangential surfaces shall be such as to give a fair average of the piece. The penetrations shall be far enough from the edge to prevent splitting or chipping.[13]

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[12] See Fig. 37 of the Appendix for a sample compression-perpendicular-to-grain data sheet form.

[13] See Fig. 38 of the Appendix for a sample data and computation sheet for the hardness test.

Speed of Testing

86. The load shall be applied continuously throughout the test at a rate of motion of the movable crosshead of 0.25 in. (6 mm) per min. (Section 128).

Weight and Moisture Content

87. The specimen shall be weighed immediately before test, and after test a moisture section approximately 1 in. (2.5 cm) in length shall be cut (Section 126).

SHEAR PARALLEL TO GRAIN

NOTE.—The following describes one method of making the shear parallel-to-grain test that has been extensively used and found satisfactory.

Size of Specimens

88. The shear-parallel-to-grain tests shall be made on 2 by 2 by $2\frac{1}{2}$-in. (5 by 5 by 6.3-cm) specimens notched as illustrated in Fig. 16 to produce failure on a 2 by 2-in. (5 by 5-cm) surface. The actual dimensions of the shearing surface shall be measured (Section 127).

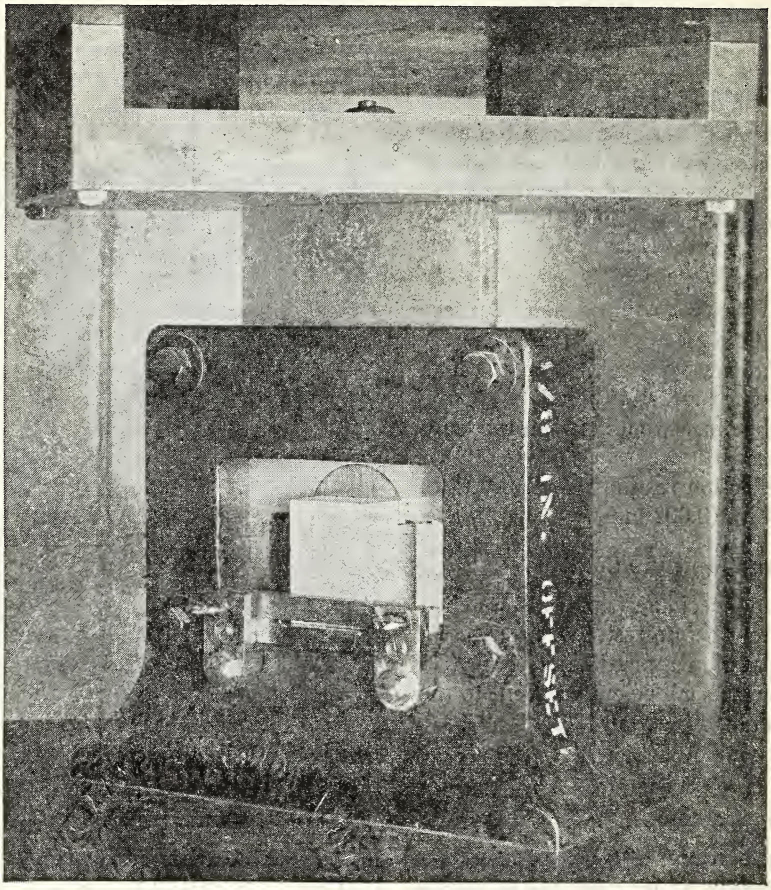

FIG. 17.—Shear-Parallel-to-Grain Test Assembly Showing Method of Load Application Through Adjustable Seat to Provide Uniform Lateral Distribution of Load.

Procedure

89. A shear tool similar to that illustrated in Fig. 17, providing a $\frac{1}{8}$-in. (3 mm) offset between the inner edge of the supporting surface and the plane along which the failure occurs, shall be used. The load shall be applied to, and the

specimen supported on, end-grain surfaces. Care shall be taken in placing the specimen in the shear tool to see that the crossbar is adjusted so that the edges of the specimen are vertical and the end rests evenly on the support over the contact area. The maximum load only shall be observed.

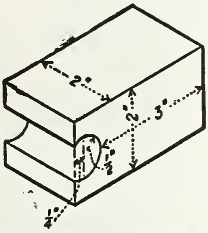

Fig. 18.—Cleavage Test Specimen.

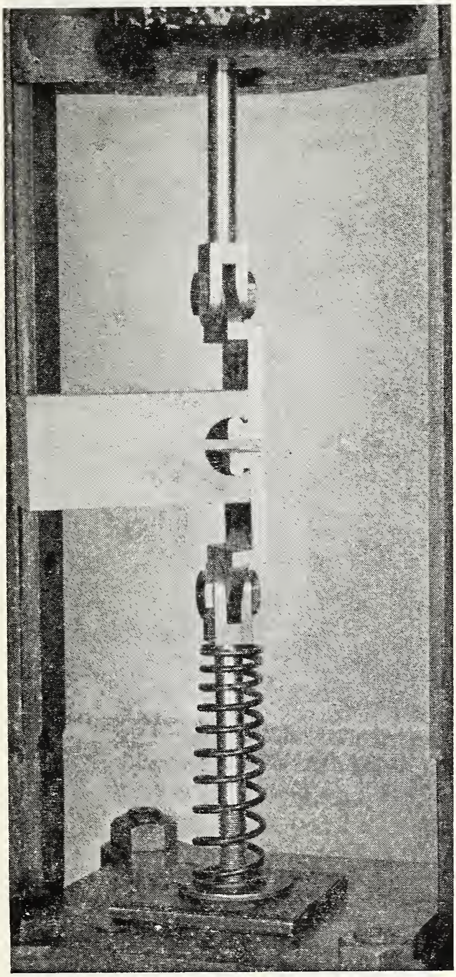

Fig. 19.—Cleavage Test Assembly.

Speed of Testing

90. The load shall be applied continuously throughout the test at a rate of motion of the movable crosshead of 0.024 in. (0.6 mm) per min. (Section 128).

Test Failures

91. The failure shall be sketched on the data sheet.[14] In all cases where the failure at the base of the specimen extends back onto the supporting surface, the test shall be culled.

Moisture Content

92. The portion of the test piece that is sheared off shall be used as a moisture specimen (Section 126).

CLEAVAGE

Size of Specimens

93. The cleavage tests shall be made on specimens of the form and size shown in Fig. 18. The actual width and length at minimum section shall be measured (Section 127).

Procedure

94. The specimens shall be held during test in grips as shown in Figs. 19 and 20. The maximum load only shall be observed.

Speed of Testing

95. The load shall be applied continuously throughout the test at a rate of motion of the movable crosshead of 0.10 in. (2.5 mm) per min. (Section 128).

Sketch of Failure

96. The failure shall be sketched on the data sheet.[15]

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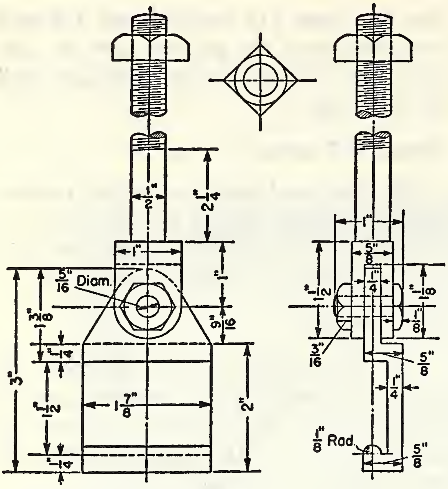
[14] See Fig. 39 of the Appendix for a sample data and computation sheet for the tangential-shear-parallel-to-grain test.

[15] See Fig. 40 of the Appendix for a sample data and computation sheet for the cleavage test.



Note-Two pieces included in one set:
One piece with shank 8" long.
One piece with shank 5 1/2" long.

Fig. 20.—Design Details of Grips for Cleavage Test.

Moisture Content

97. One of the pieces remaining after failure, or a section split along the surface of failure, shall be used as a moisture specimen (Section 126).

Tension Parallel to Grain

Note.—One method of determining the tension-parallel-to-grain strength of wood is given in the following procedure.

Size of Specimens

98. The tension-parallel-to-grain tests shall be made on specimens of the size and shape shown in Fig. 21. The specimen shall be so oriented that the direction of the annual rings at the critical section, as shown on the ends of the specimens, shall be perpendicular to the greater cross-sectional dimension. The actual cross-sectional dimensions at min-

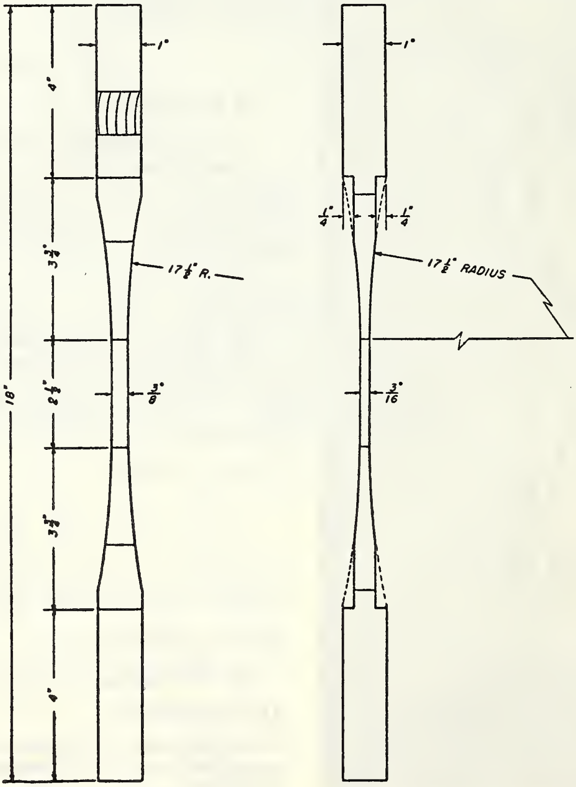


Fig. 21.—Tension-Parallel-to-Grain Test Specimen.

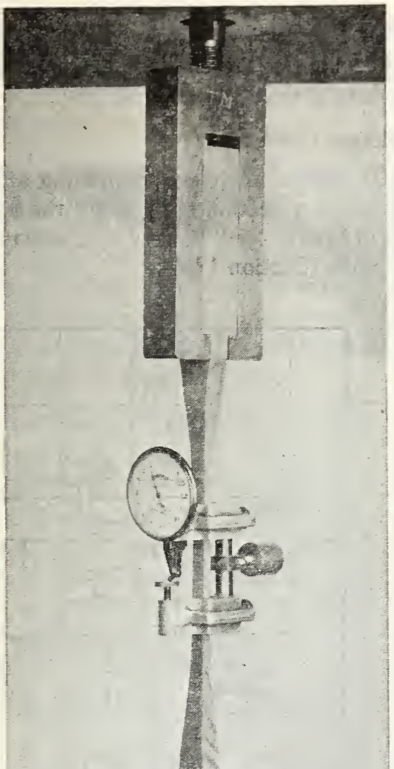


FIG. 22.—Tension-Parallel-to-Grain Test Assembly Showing Grips and Use of 2-in. Gage Length Extensometer for Measuring Deformation.

imum section shall be measured (Section 127).

Procedure

99. (*a*) The specimen shall be held in special grips (Fig. 22). Load extension curves shall be taken for a 2-in. (5 cm) central gage length on all specimens. The load-extension readings shall be continued until the proportional limit is passed.

(*b*) Deformations shall be read to 0.0001 in. (0.002 mm).

(*c*) Figure 22 illustrates gripping devices and a type of extensometer that have been found satisfactory.

Speed of Testing

100. The load shall be applied continuously throughout the test at a rate of motion of the movable crosshead of 0.05 in. (1 mm) per min. (Section 128).

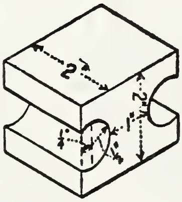


FIG. 23.—Tension-Perpendicular-to-Grain Test Specimen.

Sketch of Failure

101. The failure shall be sketched on the data sheet.[16]

Moisture Content

102. A moisture section about 3 in. (7.5 cm) in length shall be cut from the reduced section near the failure (Section 126).

TENSION PERPENDICULAR TO GRAIN
(Optional Test)

Size of Specimens

103. The tension - perpendicular-to-grain tests shall be made on specimens of the size and shape shown in Fig. 23. The actual width and length at minimum

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[16] See Fig. 41 of the Appendix for a sample tension-parallel-to-grain data and computation sheet.

sections shall be measured (Section 127).

Procedure

104. The specimens shall be held during test in grips as shown in Figs. 24 and 25. The maximum load only shall be observed.

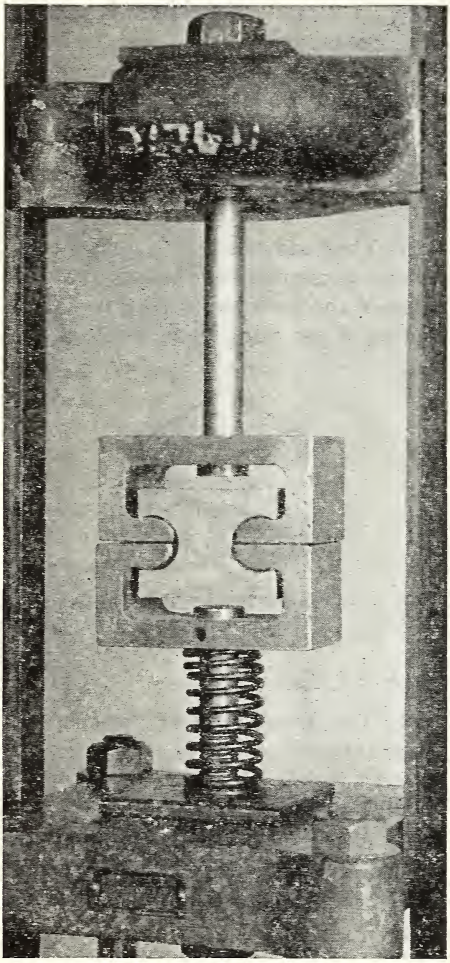


FIG. 24.—Tension-Perpendicular-to-Grain Test Assembly.

Speed of Testing

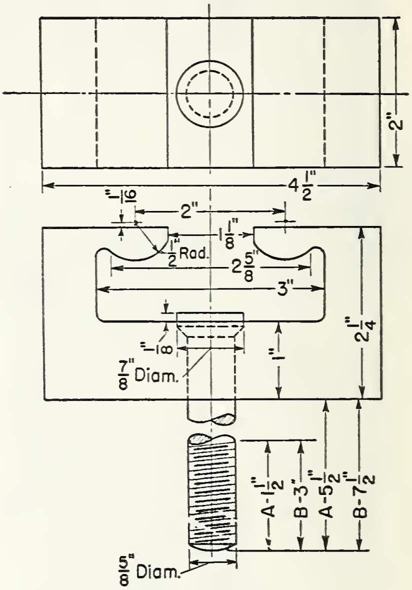
105. The load shall be applied continuously throughout the test at a rate of motion of the movable crosshead of 0.10 in. (2.5 mm) per min. (Section 128).

Sketch of Failure

106. The failure shall be sketched on the data sheet.[17]

Moisture Content

107. One of the pieces remaining after failure, or a section split along the surface of failure, shall be used as a moisture specimen (Section 126).



Note-Two pieces included in one set:
One marked A.
One marked B.

Scale-Full Size

FIG. 25.—Design Details of Grips for Tension-Perpendicular-to-Grain Test.

NAIL WITHDRAWAL

(Optional Test)

NOTE.—Presented herewith is a recommended procedure for making mail withdrawal tests. When necessary, alternate procedures that give comparable results may be used.

Size of Specimens

108. The nail withdrawal tests shall be made on 2 by 2 by 6-in. (5 by 5 by 15-

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[17] See Fig. 42 of the Appendix for a sample data and computation sheet for the tension-perpendicular-to-grain test.

cm) specimens. The actual cross-sectional dimensions and length shall be measured (Section 127).

Nails

109. Nails used for withdrawal tests shall be nominally 0.0985 inch (2.5 mm) in diameter.[17a] Bright diamond-point nails shall be used, and all nails shall be cleaned before use to remove any coating or surface film that may be present as a result of manufacturing operations. Each nail shall be used but once.

Preparation of Specimens

110. Nails shall be driven at right angles to the face of the specimen to a total penetration of 1¼ in. (3.2 cm). Two nails shall be driven on a tangential surface, two on a radial surface, and one on each end. The choice between the two radial and between the two tangential surfaces shall be such as to give a fair average of the piece. On radial and tangential faces, the nails shall be driven a sufficient distance from the edges and ends of the specimen to avoid splitting. In general, nails should not be driven closer than ¾ in. (18 mm) from the edge or 1½ in. (37 mm) from the end of a piece, and the two nails on a radial or tangential face should not be driven in line with each other or less than 2 in. (5 cm) apart.

Procedure

111. All six nails in a single specimen shall be withdrawn immediately after driving. The specimens shall be held during the test in grips as shown in Figs. 26 and 27. The maximum load only shall be observed.[17b]

Speed of Testing

112. The load shall be applied continuously throughout the test at a rate of motion of the movable crosshead of 0.075 in. (2 mm) per min (Section 128).

Weight and Moisture Content

113. The specimen shall be weighed immediately before driving the nails and after test a moisture section approximately 1 in. (2.5 cm) in length shall be cut from the body of the specimen (Section 126).

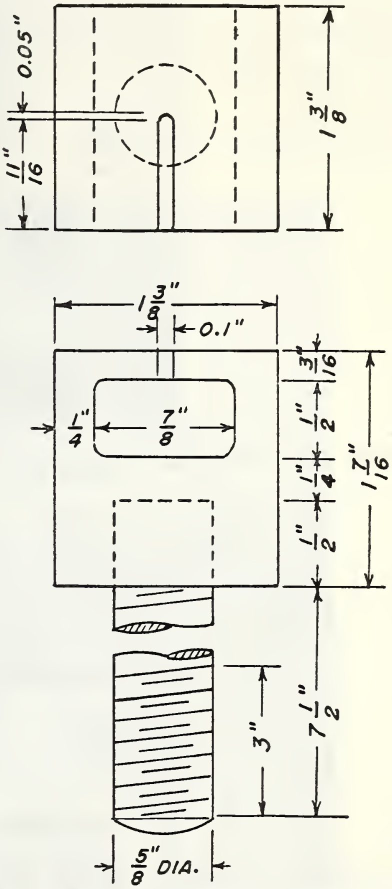

FIG. 26.—Design Details of Grip for Nail Withdrawal Test.

SPECIFIC GRAVITY AND SHRINKAGE IN VOLUME

Size of Specimens

114. The specific gravity and shrinkage in volume tests shall be made on

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[17a] A fivepenny common nail meets this requirement. If difficulty is experienced in woods of higher density in pulling the nails without breaking the heads, a sevenpenny, cement-coated sinker nail, with coating removed by use of a suitable solvent, may be used.

[17b] See Fig. 43 of the Appendix for a sample nail-withdrawal test data sheet form.

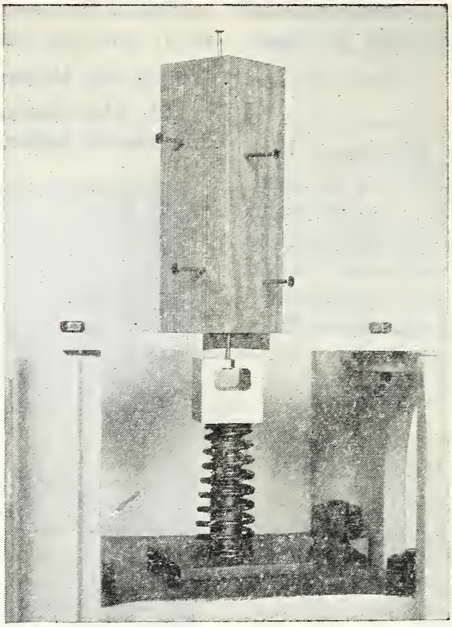

FIG. 27—Nail Withdrawal Test Assembly Showing Specimen in Position for Withdrawal of Nail Driven in One End of the Specimen.

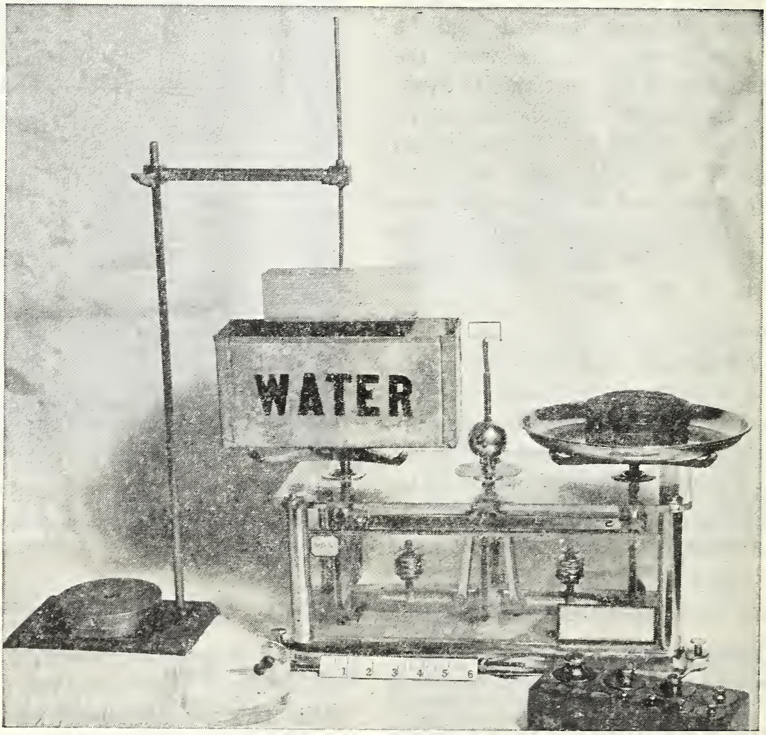

FIG. 28.—Specific Gravity and Shrinkage-in-Volume Test Set-Up.

2 by 2 by 6-in. (5 by 5 by 15-cm) specimens. The actual cross-sectional dimensions and length shall be measured (Section 127).

Procedure

115. (*a*) Both specific gravity and shrinkage-in-volume determinations shall be obtained on the same specimen. These determinations should be made at approximately 12 per cent moisture content and in the oven-dry condition.

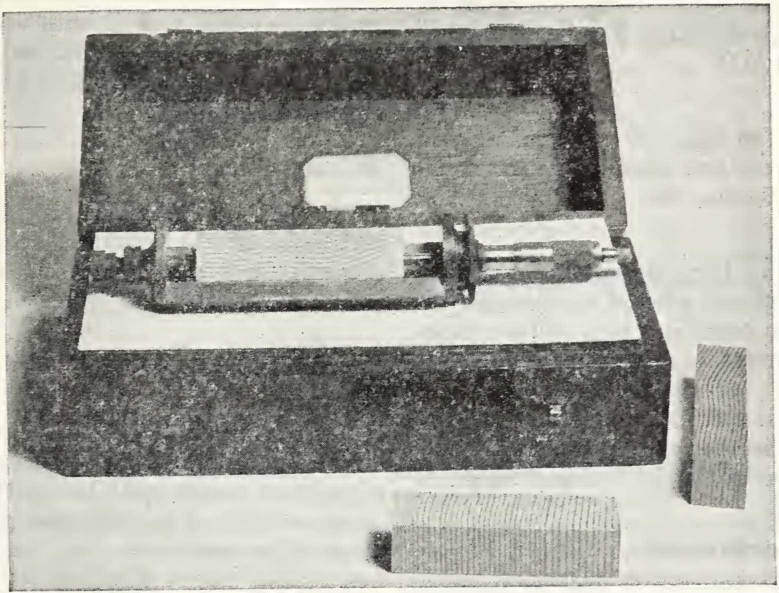

FIG. 29.—Radial- and Tangential-Shrinkage Test Assembly.

(*b*) A carbon impression of the end of the green specimen may be made on the back of the data sheet.[18] In like manner, a carbon impression of the same end may be made after the specimen has been conditioned (Paragraphs (*d*) and (*e*)).

(*c*) The specimen shall be weighed when green (Section 126) and the volume shall be determined by the immersion method.

(*d*) The green specimens after immersion shall be open-piled and allowed to air-season under room conditions to a uniform moisture content of approximately 12 per cent. The specimens should then be weighed and the volume determined by the immersion method.

(*e*) The specimens used for specific gravity and shrinkage determinations at 12 per cent moisture content, or duplicate specimens on which green weight and volume measurements have been made prior to conditioning to approximately 12 per cent moisture content, shall then be open-piled in an oven and dried at 103 ± 2 C until approximately constant weight is reached.

(*f*) After oven-drying, the specimens shall be weighed (Section 126) and while still warm shall be immersed in a hot paraffin bath, care being taken to remove them quickly to ensure a thin coating.

(*g*) The volume of the paraffin-coated specimen shall be determined by immersion as before.

(*h*) Fig. 28 illustrates the apparatus used in determining the specific gravity and shrinkage in volume. The use of an automatic balance will facilitate increased rapidity and accuracy of measurements.

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[18] See Fig. 44 of the Appendix for a sample data and computation sheet for the specific gravity and shrinkage-in-volume test.

RADIAL AND TANGENTIAL SHRINKAGE

Size of Specimen

116. The radial- and tangential-shrinkage determinations shall be made on 1 by 4 by 1-in. (2.5 by 10 by 2.5-cm) specimens.

Initial Measurement

117. The specimen shall be measured across the 4-in. (10-cm) dimension in which the shrinkage is to be determined (Section 127).

Weight

118. The specimen shall be weighed when green and after subsequent oven-drying (Section 126).

Drying

119. (*a*) The green specimens shall be open-piled and allowed to air-season under room conditions to a uniform moisture content of approximately 12 per cent.

(*b*) The specimens shall then be open-piled in an oven and dried at 103 ± 2 C until approximately constant weight is attained.

Final Measurement

120. Measurements shall be made on the air-dry and on the oven-dry specimens.[19]

Method of Measurement

121. Figure 29 illustrates the method of making the radial- and tangential-shrinkage measurements. An ordinary micrometer of required accuracy is suitable for this work (Section 127).

MOISTURE DETERMINATION

Selection

122. The sample for moisture determinations of each test specimen shall be selected as hereinbefore described for each test.

Weighing

123. Immediately after obtaining the moisture sample, all loose splinters shall be removed and the sample shall be weighed (Section 126).

Drying

124. The moisture samples shall be open-piled in an oven and dried at a temperature of 103 ± 2 C until approximately constant weight is attained, after which the oven-dry weight shall be determined (Section 125).

Moisture Content

125. The loss in weight, expressed in percentage of the oven-dry weight as above determined, shall be considered the moisture content of the specimen.

PERMISSIBLE VARIATIONS

Weights

126. The weight of test specimens and of moisture samples shall be determined to an accuracy of not less than plus or minus 0.2 per cent.

Measurements

127. Measurements of test specimens shall be made to an accuracy of not less than ±0.3 per cent, except that in no case shall the measurements be made to less than 0.01 in. (0.2 mm), except measurements of the radial and tangential shrinkage specimens that shall be made to the nearest 0.001 in. (0.02 mm).

Testing Machine Speeds

128. The testing machine speed used should not vary by more than plus or minus 25 per cent from that specified for a given test. If the specified speed can-

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[19] See Fig. 45 of the Appendix for a sample data and computation sheet for the radial- and tangential-shrinkage test.

not be obtained, the speed used shall be recorded on the data sheet. The crosshead speed shall mean the free-running or no-load speed of crosshead for testing machines of the mechanical drive type and the loaded crosshead speed for testing machines of the hydraulic loading type.

CALIBRATION

Calibration

129. All apparatus used in obtaining data shall be calibrated at sufficiently frequent intervals to insure accuracy.[20]

PART II. SECONDARY METHOD

Part II, Secondary Method, is intended for use in evaluating the properties of wood only when relatively small trees, generally less than 12 in. in diameter, are available to provide the test specimens and only when such trees because of crook, cross grain, knots or other defects are of such quality that the longer clear, straight-grained specimens required by Part I, Primary Method, can not reasonably be obtained. Whenever possible, the procedure for Part I, Primary Method, shall be used regardless of size of trees.

INTRODUCTION

The standard methods of testing small clear specimens of timber, Part I, Primary Method, provide for cutting the bolts (log sections) systematically into sticks of nominal 2½ by 2½ in. in cross-section, that are later surfaced to provide the test specimens 2 by 2 in. in cross-section, on which the system is based. These methods have served as an excellent basis for the evaluation of the various mechanical and related physical properties of different species of wood. They have been extensively used, and a large amount of data based on these methods have been obtained and published.

The 2 by 2-in. test specimen has the advantage that it embraces a number of growth rings, is less influenced by springwood and summerwood differences than smaller specimens, and is large enough to represent a considerable proportion of the material. Because of the cross-sectional size and the length of specimen required for some of the tests (30 in. for static and impact bending) it is, however, sometimes difficult to obtain test specimens in adequate number and entirely free from defects from bolts representing smaller trees, particularly trees under 12 to 15 in. in diameter. With increasing need for evaluating the properties of species involving smaller trees, and the increasing importance of second-growth timber that is expected to be harvested much before it reaches the sizes attained in virgin stands, there has developed a need for a secondary method of test in which at least the longer test specimens are smaller than 2 by 2 in. in cross-section. It is axiomatic that test results are intimately related to and dependent upon the test methods employed. The problem has hence been to develop a secondary method that gives test results directly comparable to those obtained by the present primary method employing a 2 by 2-in. cross-section for all test specimens, and thus insure a continuing accumulation of data directly comparable to the extensive data already available. Such a method is provided by Part II, Secondary Method, for testing small clear specimens of timber.

The exceedingly rapid rate of growth and corresponding wide annual rings in much second-growth material, together with the desirability of incorporating more than a single year's growth increment in a test specimen, has necessitated limiting the minimum cross-section of test piece in this secondary method to 1 by 1 in. This cross-section is established for the compression-parallel-to-grain and static-bending tests. The 2 by 2-in. cross-section is retained for impact bending, and for the other tests not requiring specimens longer than 6 in.: namely, compression perpendicular to grain, hardness, shear parallel to grain, cleavage, and tension perpendicular to grain. Toughness and tension parallel to grain are special tests based on specimens of smaller cross-section.

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[20] Tentative Methods of Verification of Testing Machines (A.S.T.M. Designation: E 4), see p. 895.

Investigations have shown that for the more important properties obtained from static bending and compression parallel to grain tests (modulus of rupture and modulus of elasticity in static bending, and maximum crushing strength and modulus of elasticity in compression parallel to grain) results from specimens of 1 by 1-in. in cross-section can be substituted directly for those obtained from specimens of 2 by 2-in. in cross-section with but little error. Present data indicate that values of fiber stress at proportional limit in static bending and in compression parallel to grain may be slightly higher for the 1 by 1-in. than for the 2 by 2-in. specimens, based on standardized testing procedures appropriate to the two sizes, but no special reason why this should be expected is apparent. The work values in static bending, however, are related somewhat to size of specimen, and total work also to the arbitrary load and deflection limit established for terminating the test. The relationship of work values for the two sizes also varies among different species, hence work values in static bending should not be regarded as directly comparable as between the Primary Method and the Secondary Method. In reporting results of tests it is recommended that the size of specimen be given, or that the data be referenced to the Primary or Secondary Method.

Since exactly the same size and form of test specimens for compression perpendicular to grain, hardness, impact bending, shear parallel to grain, cleavage, tension parallel to grain, tension perpendicular to grain, and toughness are used for the Primary and the Secondary Methods, identical test results are obviously obtained.

Since the procedure for the Secondary Method for many features, such as in selection and care of material, and in conducting certain tests, is identical with the Primary Method, the Secondary Method presented herewith is referenced to the Primary Method, and procedure is given only where it differs therefrom. For convenience the paragraph numbers in the Secondary Method correspond in the last two digits with the numbering of the Primary Method but the numbering begins with 201 in the former. Thus Paragraph 201 in the Secondary Method corresponds in subject matter to Paragraph 1 of the Primary Method, etc.

Purpose of Tests

201. See Section 1.

Kind of Tests

202. (*a*) See Section 2(*a*).

(*b*) The procedures for collection and preparation of the material for testing and for the various tests appear in the following order:

SECTIONS

Collection of Material:

Selection.................... 203 to 207
Field Marking................ 208 to 212
Field Descriptions............ 213
Preparation for Shipment...... 214

Disposition at Destination:

Storage of Logs at Destination.. 215
Photographing, Sawing, and Final Marking.............. 216 to 218
Matching for Tests of Air-Dry Material.................. 219 and 220
Disposition of Sticks........... 221 and 222

Order, Selection, and Number of Tests...................... 223
Selection of Specimens......... 224 to 226
Number of Tests for each Bolt.. 227 to 240
Photographs of Sticks........... 241
Control of Moisture Content and Temperature............... 242 and 243

Record of Heartwood and Sapwood 244
Static Bending .... 245 to 252
Compression Parallel to Grain .... 253 to 260
Impact Bending .... 261 to 270
Toughness .... 271 to 276
Compression Perpendicular to Grain .... 277 to 282
Hardness .... 283 to 287
Shear Parallel to Grain .... 288 to 292
Cleavage .... 293 to 297
Tension Parallel to Grain .... 298 to 302
Tension Perpendicular to Grain .... 303 to 307
Nail Withdrawal .... 308 to 313
Specific Gravity and Shrinkage in Volume .... 314 and 315
Radial and Tangential Shrinkage .... 316 to 321
Moisture Determination .... 322 to 325
Permissible Variations .... 326 to 328
Calibration 329

COLLECTION OF MATERIAL

Selection

Authentic Identification

203. See Section 3.

Selection and Number of Trees

204. For each species to be tested, at least ten trees representative of the species shall be selected.

Selection and Number of Bolts

205. (*a*) See Section 5 (*a*).

(*b*) From the other trees called for in Section 204, take the 8-ft. section[21] (*c-d* bolts) next above the 8-ft. butt log if this section falls within the merchantable length of the tree, otherwise take the 8-ft. section comprising the two highest standard bolts (multiples of 4-ft.) within the merchantable length.

Substitution of Flitches for Bolts

206. For the small trees to which this secondary method is applicable, bolts representing the full diameter of the log are required, and flitches should not be substituted for bolts.

Selection for Important Species

207. For important species of wide geographical distribution, test material shall be selected from two or more localities or sites. The number of trees of a species selected from each site or locality shall conform to the requirements of Sections 204 and 205.

Field Marketing

Tree Designation

208. See Section 8.

Bolt Designation

209. See Section 9.

Manner of Marking

210. See Section 10.

Indication of Cardinal Point

211. See Section 11.

Shipment Number

212. See Section 12.

Field Descriptions

Field Descriptions

213. See Section 13.

Preparation for Shipment

Preparation for Shipment

214. See Section 14.

DISPOSITION AT DESTINATION

Storage of Logs at Destination

Storage of Logs

215. See Section 15.

Photographing, Sawing, and Final Marking

NOTE.—In sawing, marking, and selecting test sticks, the aim should be to obtain specimens representative of the material collected. The procedure described herein is one that has been found satisfactory for most species.

Photographing Ends of Bolts

216. See Section 16.

Sawing of Bolts

217. All bolts shall be marked on the top end into $2\frac{1}{2}$ by $2\frac{1}{2}$-in. or $1\frac{1}{4}$ by $1\frac{1}{4}$-in. squares as shown in Fig. 30, and sawed

---

[21] The 8-ft. lengths specified are intended to provide test material in sticks of this net length. It is recommended that the bolts or sections be cut in the woods to 9-ft. lengths, to allow for trimming, etc.

into nominal 2½ or 1¼-in. sticks. The letters *N*, *E*, *S*, and *W* indicate the cardinal points. For trees that are not circular or for intermediate sizes where more than the required distance is available, sticks may be moved outward toward the periphery to whatever position between the pith and bark would produce sticks with a minimum of defects. For example, in trees 9 to 12 in. in diameter, sticks *N*1-4 and *S*1-4 could be moved outward as much as 1½ in. if desired.

NOTE.—Sticks cut from the *N-S* axis shall be 2½ by 2½ in. when green. Sticks cut from the *E-W* axis shall be 1¼ by 1¼ in. when green.

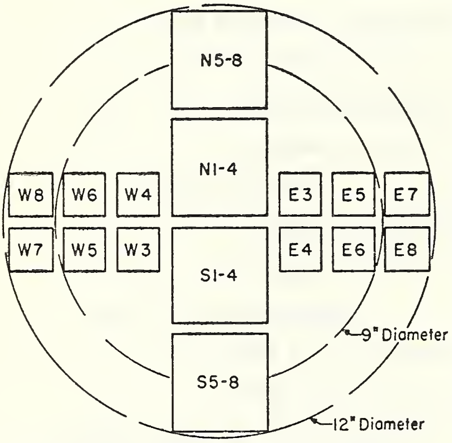

FIG. 30.—Sketch Showing Method of Cutting Up the Bolt and Marking the Sticks for the Secondary Method.

Marking of Test Sticks

218. All test sticks shall bear the shipment number, the tree number, stick number, and bolt designation, to be known respectively as Shipment No., Piece No., Stick No., and Mark. Thus, 800-1-*N*1-4*d* represents the 2½ by 2½-in. Stick *N*1-4 of Bolt *d*, Tree 1, Shipment 800, and 800-1-*W*4*c* represents the 1¼ by 1¼-in. Stick *W*4 of Bolt *c*, Tree 1, Shipment 800.

Matching for Tests of Air-dry Material

Composite Bolts

219. (*a*) The collection of material (Section 205) has been arranged to provide for tests of both green and air-dry specimens that are closely matched by selection from adjacent parts of the same tree. The 8-ft. long bolts, after being marked in accordance with Section 217, shall be sawed into 2½ by 2½-in. or 1¼ by 1¼ in. by 8-ft. sticks, and numbered and lettered in accordance with Section 218. Each 8-ft. stick shall then be cut into two 4-ft. pieces, making sure that each part carries the proper designation and bolt letter. If the 8-ft. bolt is not straight it may be found more desirable to cut it into 4-ft. lengths before cutting the 2½-or 1¼-in. square pieces. If this is done care shall be taken to secure end-matched sticks in the two 4-ft. bolts, and to insure that each part carries the proper designation and bolt letter.

(*b*) Part of the 2½ by 2½ in. and 1¼ by 1¼ in. by 4-ft. sticks from each 8-ft. bolt is to provide specimens to be tested green (unseasoned) and the other part is to provide specimens to be air-dried and tested. To afford matching, the 4-ft. sticks of one bolt shall be interchanged with the 4-ft. sticks of the next adjacent bolt from the same tree to form two composite bolts, each being complete and being made of equal portions of the adjacent 4-ft. bolts. The sticks from one of these composite bolts shall be tested green and those from the other shall be tested after air-drying. Thus, the sticks of each composite bolt shall be regarded as if they were from the same bolt.

(*c*) The above procedure provides for end-to-end matching (end matching) of sticks to be tested air-dry with those to be tested green, which is to be preferred when practicable. If, because of the nature of the material, end matching is not practicable, side matchingof 1¼ by 1¼-in. sticks may be used.

Schedule for Forming Composite Bolts

220. (*a*) The division of sticks into composite bolts, part to be tested green and part to be air-dried and tested, shall

be made according to the following schedule, in which the numbers refer to stick numbers:

SELECTION OF STICKS FROM BOLTS

Composite Bolt (ab, cd, etc.) to be Tested Green:	
Lower bolt......	*N*1–4, *S*5–8, *E*4, *E*5, *E*8, *W*4, *W*5, *W*8
Upper bolt......	*S*1–4, *N*5–8, *E*3, *E*6, *E*7, *W*3, *W*6, *W*7
Composite Bolt (ab, cd, etc.) to be Air-dried and Tested:	
Lower bolt......	*S*1–4, *N*5–8, *E*3, *E*6, *E*7, *W*3, *W*6, *W*7
Upper bolt......	*N*1–4, *S*5–8, *E*4, *E*5, *E*8, *W*4, *W*5, *W*8

(*b*) As an example of composite bolts, assume that the full cross-section, Fig. 30, represents the end of an 8-ft. section comprising the *c* and *d* bolts.

The following sticks are selected for the composite bolt to be tested green:

2½ by 2½-in. sticks:
*N*1–4c, *N*5–8d, *S*1–4d, *S*5–8c
1¼ by 1¼-in. sticks:
E3d, E4c, E5c, E6d, E7d, E8c, W3d, W4c, W5c, W6d, W7d, W8c

The following sticks are selected for the composite bolt to be air-dried and tested:

2½ by 2½-in. sticks:
N1–4d, N5–8c, S1–4c, S5–8d
1¼ by 1¼-in. sticks:
E3c, E4d, E5d, E6c, E7c, E8d, W3c, W4d, W5d, W6c, W7c, W8d

Disposition of Sticks

Green Material

221. The sticks (2½ by 2½ in. by 4 ft., or 1¼ by 1¼ in. by 4 ft.) to be tested green, shall be kept in an unseasoned condition, while awaiting preparation for test, by being stored in a framed pit or other suitable container where they shall be close piled and covered with damp sawdust, or in some other suitable manner. As material is required for test, it shall be removed from this pit or container, surfaced on all four sides to 2 by 2 in. (5 by 5 cm) or 1 by 1 in. (2.5 by 2.5 cm) cross-section, sawed to test size, and kept covered with a damp cloth in a tightly closed container at a temperature of about 20 ± 3 C (68 ± 6 F) (See Note, Section 22 (*e*)) until the time of test. Care shall be taken to avoid as much as possible the storage of green material in any form. Sticks to be tested in a green condition usually should not be sawed from the log form in quantities greater than is required to meet the testing demands for from a few days to not more than two weeks, depending on the prevailing conditions.

Air-dry Material

222. (*a*) The ends of the sticks to be air-dried (2½ by 2½ in. by 4 ft., or 1¼ by 1¼ in. by 4 ft.) shall be dipped in melted paraffin or other substance suitable to retard checking. The material shall be piled so as to have a space of at least ½ in. on each side of each stick to permit circulation of air. The material shall be stored in a place allowing free access of air, but protected from sunshine, rain, snow, and moisture from the ground. The sticks in drying shall not be subjected to artificial heat.

(*b*) See Section 22 (*b*).

(*c*) When the material has reached equilibrium, moisture sections approximately 1 in. (2.5 cm) in length shall be taken from about 10 per cent of the sticks to determine the actual moisture content. These moisture specimens shall be cut not less than 1 ft. (30 cm) from the ends of the sticks, and in such a way as to prevent any appreciable loss of material for testing. When conditioned to approximately 12 per cent moisture content the sticks shall be surfaced on four sides to 2 by 2 in. (5 by 5 cm) or 1 by 1 in. (2.5 by 2.5 cm) in cross-section, sawed to test size, and tested.

(*d*) See Section 22 (*d*).

(*e*) See Section 22 (*e*).

ORDER, SELECTION, AND NUMBER OF TESTS

Order of Tests

223. See Section 23.

Selection of Specimens

Preference in Selecting Specimens

224. In case the material from a given bolt should be insufficient to furnish all

the test specimens hereinafter required, additional bolts may be selected. If additional material is not available, the preferential order of mechanical tests to be used in selecting specimens shall be as follows: Static bending, compression parallel to grain, impact bending, toughness, compression perpendicular to grain, hardness, shear parallel to grain, cleavage, tension parallel to grain, tension perpendicular to grain, and nail withdrawal.

Test Pieces from Bending Specimens After Failure

225. See Section 25.

Quality of Test Material

226. See Section 26.

Number of Tests for Each Bolt

Static Bending

227. One static bending specimen shall be taken from each pair of $1\frac{1}{4}$ by $1\frac{1}{4}$-in. sticks. A pair consists of two adjacent sticks equidistant from the pith, as *W*7 and *W*8, Fig. 30. In the composite bolts tested to afford a comparison of the strength of green and air-dry material, the pair of sticks shall be constituted as above, except that the sticks in this case will be from different bolts. Thus, *W3d* and *W4c* constitute one pair of sticks to be tested green, and *W3c* and W4*d* the corresponding pair to be tested air-dry (Section 220). Effort shall be made to select sticks so that both bolts of the composite bolt are represented in the green and the dry tests.

Compression Parallel to Grain

228. One compression-parallel-to-grain specimen shall be taken from each pair of $1\frac{1}{4}$ by $1\frac{1}{4}$-in. sticks, as for static bending. Effort shall be made to select sticks so that both bolts of a composite bolt are represented in the green and the dry tests. Load-compression curves shall preferably be taken on all of the specimens.

Impact Bending

229. One impact bending specimen shall be taken from each of 50 per cent of the $2\frac{1}{2}$ by $2\frac{1}{2}$-in. sticks from each bolt. Effort shall be made to secure the best possible representation of the cross-section.

Toughness

230. Two toughness specimens shall be selected from each stick used for static bending.

Compression Perpendicular to Grain

231. One compression-perpendicular-to-grain specimen shall be taken from each $2\frac{1}{2}$ by $2\frac{1}{2}$-in. stick selected for impact bending specimens.

Hardness

232. One hardness specimen shall be taken from each $2\frac{1}{2}$ by $2\frac{1}{2}$-in. stick used for impact bending and compression-perpendicular-to-grain tests.

Shear Parallel to Grain

233. Two shear-parallel-to-grain specimens shall be selected from each of the $2\frac{1}{2}$ by $2\frac{1}{2}$-in. sticks from each bolt remaining after selection of sticks for impact bending tests. One of each pair of specimens from the same stick shall be tested in radial shear (surface of failure radial) and the other in tangential shear (surface of failure tangential).

Cleavage Perpendicular to Grain

234. Two cleavage specimens shall be taken from each of the $2\frac{1}{2}$ by $2\frac{1}{2}$-in. sticks selected for shear-parallel-to-grain specimens. One of each pair of specimens from the same stick shall be tested in radial cleavage (surface of failure radial) and the other in tangential cleavage (surface of failure tangential).

Tension Parallel to Grain

235. One tension-parallel-to-grain specimen shall be taken from each pair of $1\frac{1}{4}$ by $1\frac{1}{4}$-in. sticks.

Tension Perpendicular to Grain

236. Two tension-perpendicular-to-grain specimens shall be taken from each of the $2\frac{1}{2}$ by $2\frac{1}{2}$-in. sticks selected for shear-parallel-to-grain specimens. One of each pair of specimens from the same stick shall be tested in radial tension (surface of failure radial) and the other in tangential tension (surface of failure tangential).

Nail Withdrawal

237. Four nail withdrawal specimens shall be selected from the uninjured portion of 2 by 2-in (5 by 5-cm) specimens from other tests, selected to give satisfactory representation of the cross-section of the bolt. Two specimens shall be tested in the green condition and two in the air-dry condition.

Specific Gravity and Shrinkage in Volume

238. Two to four specific gravity and shrinkage-in-volume specimens shall be selected from the unused portions of $2\frac{1}{2}$ by $2\frac{1}{2}$-in. sticks, selected to give the best possible representation of the cross-section and tree heights included in composite bolts. These specimens shall be selected only from the sticks to be tested in a green condition.

Radial Shrinkage

239. Two radial shrinkage specimens shall be obtained from each *d* bolt, and where possible from the upper bolt of each pair of bolts selected at other heights in the tree. They shall be cut from disks cut from near the end of the bolt. Care shall be taken to see that the disks are green and have not been affected by shrinking and checking which is common near the end of the bolt. The specimens shall not be surfaced. Radial shrinkage specimens shall be cut with their greatest dimension in the radial direction. One specimen shall be taken outward from near the pith and the other inward from near the bark.

Tangential Shrinkage

240. Two tangential shrinkage specimens shall be obtained from each *d* bolt, and where possible from the upper bolt of each pair of bolts selected at other heights in the tree. They shall be selected at the same time and in a manner similar to radial-shrinkage specimens (Section 239), except that the greatest dimension shall be in a tangential direction. The specimens shall not be surfaced. One shall be taken from near the periphery and the other nearer the pith to represent an earlier period of growth. The tangential-shrinkage specimens shall be adjacent to the specimens selected for radial shrinkage.

PHOTOGRAPHS OF STICKS

Sticks to be Photographed

241. Four of the static bending sticks from each species shall be selected for photographing as follows: two average growth, one fast growth, and one slow growth. These sticks shall be photographed in cross-section and on the radial and tangential surfaces. Figure 4 is a typical photograph of a cross-section of 2 by 2-in. (5 by 5-cm) test specimens, and Fig. 5 of the tangential surface of such specimens.

CONTROL OF MOISTURE CONTENT AND TEMPERATURE

NOTE.—In recognition of the significant influence of temperature and humidity on the strength of wood, it is highly desirable that these factors be controlled to insure comparable test results.

Control of Moisture Content

242. See Section 42.

Control of Temperature

243. See Section 43.

RECORD OF HEARTWOOD AND SAPWOOD

Proportion of Sapwood

244. See Section 44.

STATIC BENDING

Size of Specimens

245. The static bending tests shall be made on nominal 1 by 1 by 16-in. (2.5 by 2.5 by 41 cm) specimens. The actual height and width at the center, and the length shall be measured (Section 127).

Loading Span and Supports

246. Center loading and a span length of 14 in. (35 cm) shall be used. Both supporting knife edges shall be provided with bearing plates and rollers of such thickness that the distance from the point of support to the central plane is not greater than the depth of the specimen (Fig. 6). The knife edges shall be adjustable laterally to permit adjustment for slight twist or warp in the specimen.[22] Alternatively, the method of supporting the specimen in trunnion-type supports which are free to move in a horizontal direction may be employed.

Loading Block

247. A loading block having a radius of curvature of $1\frac{1}{2}$ in. (3.7 cm) for a chord length of not less than 2 in. (5 cm) shall be used.

Placement of Growth Rings

248. See Section 48.

Speed of Testing

249. The load shall be applied continuously throughout the test at a rate of the movable crosshead of 0.05 in. (1.3 mm) per min. (Section 128).

Load-deflection Curves

250. (*a*) Load-deflection curves shall be taken to or beyond the maximum load for all static bending tests. In at least one-third of the tests, the curves shall be continued to a 3-in. (7.5 cm) deflection, or until the specimen fails to support a load of 50 lb. (22.5 kg)

(*b*) See Section 50 (*b*).

(*c*) See Section 50 (*c*).

(*d*) See Section 50 (*d*).

Description of Static Bending Failures

251. See Section 51.

Weight and Moisture Content

252. See Section 52.

COMPRESSION PARALLEL TO GRAIN

Size of Specimens

253. The compression-parallel-to-grain tests shall be made on nominal 1 by 1 by 4-in. (2.5 by 2.5 by 10-cm) specimens. The actual cross section dimensions and the length shall be measured (Section 127).

End Surfaces Parallel

254. See Section 54.

Speed of Testing

255. See Section 55.

Load-compression Curves

256. (*a*) Load-compression curves shall be taken over a central gage length of 2

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[22] Details of laterally adjustable supports may be found in Fig. 4 of the Standard Methods of Testing Veneer, Plywood, and Other Glued Veneer Constructions (A.S.T.M. Designation: D 805), p. 57.

in. (5 cm), and preferably on all of the specimens. Load-compression readings shall be continued until the proportional limit is well passed, as indicated by the curve.[23]

(*b*) Deformations shall be read to 0.0001 in. (0.002 mm).

(*c*) Figures 9 and 10 illustrate two types of compressometers of 6-in. (15 cm) gage length that have been found satisfactory for wood testing. Similar apparatus are available for measurements of compression over a 2-in. (5 cm) gage length.

Position of Test Failures

257. See Section 57.

Description of Compression Failures

258. See Section 58.

Weight and Moisture Content

259. See Section 59.

Ring and Summer Wood Measurement

260. See Section 60.

IMPACT BENDING

261 to 270. See Sections 61 to 70, inclusive.

TOUGHNESS

271 to 276. See Sections 71 to 76, inclusive.

NOTE.—A single blow impact test on a small specimen is recognized as a valuable and desirable test. Several types of machines such as the Toughness, Izod, and Amsler have been used, but insufficient information is available to decide whether one procedure is superior to another, or whether the results by the different methods can be directly correlated. If the Toughness machine is used, the procedure described in Sections 71 to76, inclusive, has been found satisfactory. To aid in standardization and to facilitate comparisons, the size of the toughness specimen has been made equal to that accepted internationally.

COMPRESSION PERPENDICULAR TO GRAIN

277 to 282. See Sections 77 to 82, inclusive.

HARDNESS

283 to 287. See Sections 83 to 87, inclusive.

SHEAR PARALLEL TO GRAIN

288 to 292. See Sections 88 to 92, inclusive.

NOTE.—Sections 88 to 92, inclusive, describe one method of making the shear parallel-to-grain test that has been extensively used and found satisfactory.

CLEAVAGE

293 to 297. See Sections 93 to 97, inclusive.

TENSION PARALLEL TO GRAIN

298 to 302. See Sections 98 to 102, inclusive.

NOTE.—One method of determining the tension-parallel-to-grain strength of wood is given in sections 98 to 102, inclusive.

TENSION PERPENDICULAR TO GRAIN

(Optional Test)

303 to 307. See Sections 103 to 107, inclusive.

NAIL WITHDRAWAL

(Optional Test)

308 to 313. See Sections 108 to 113, inclusive.

NOTE.—A recommended procedure for nail withdrawal test is given in Sections 108 to 113, inclusive. When necessary, alternate procedures that give comparable results may be used.

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[23] See Fig. 32 of the Appendix for a sample compression-parallel-to-grain data sheet form.

SPECIFIC GRAVITY AND SHRINKAGE IN VOLUME

314 and 315. See Sections 114 and 115.

RADIAL AND TANGENTIAL SHRINKAGE

316 to 321. See Sections 116 to 121, inclusive.

MOISTURE DETERMINATION

322 to 325. See Sections 122 to 125, inclusive.

PERMISSIBLE VARIATIONS

326 to 328. See Sections 126 to 128, inclusive.

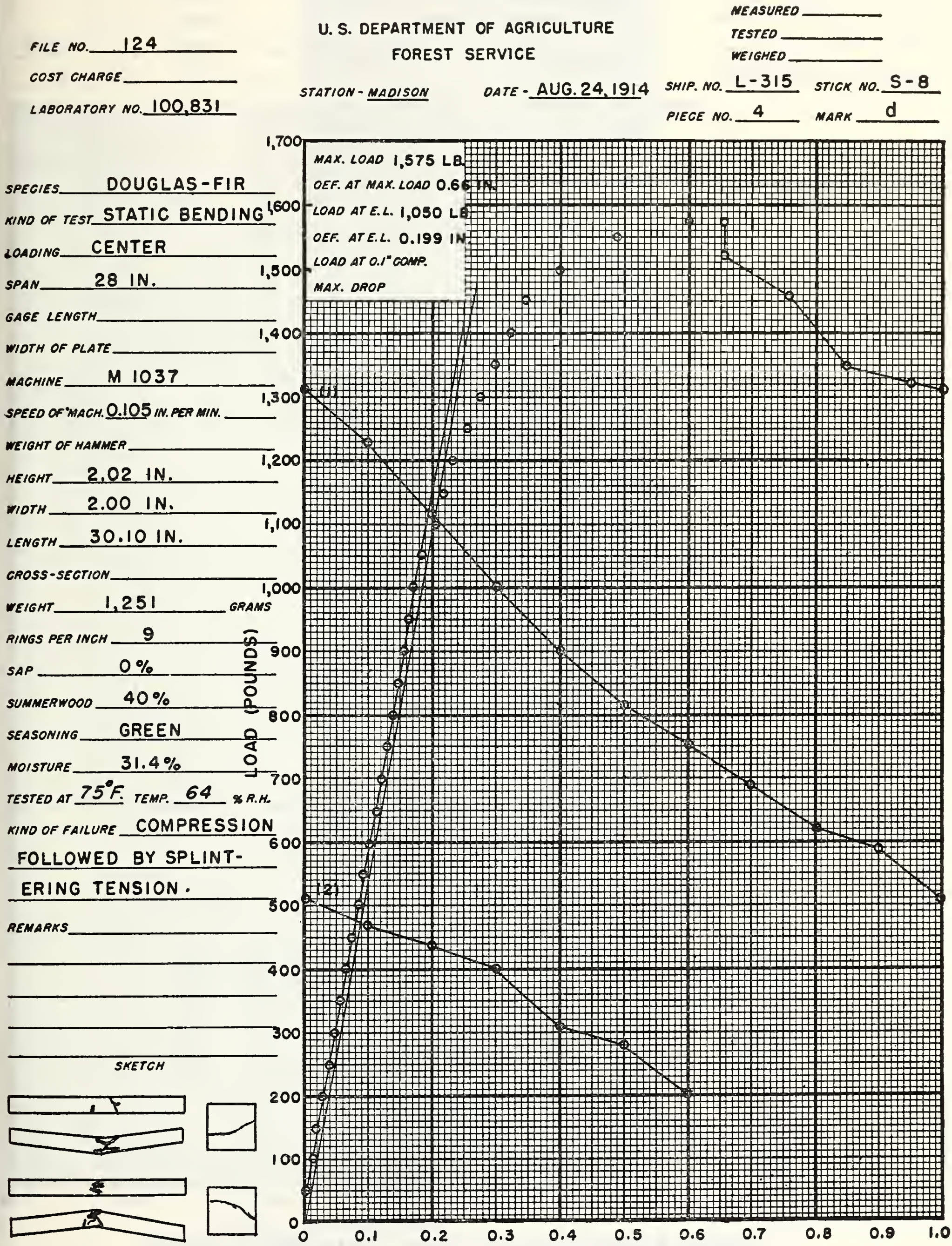
CALIBRATION

Calibration

329. See Section 129.

(See Figs. 31 to 45, and Table I on pp. 39 to 56.)

APPENDIX



U. S. DEPARTMENT OF AGRICULTURE
FOREST SERVICE

MEASURED
TESTED
WEIGHED

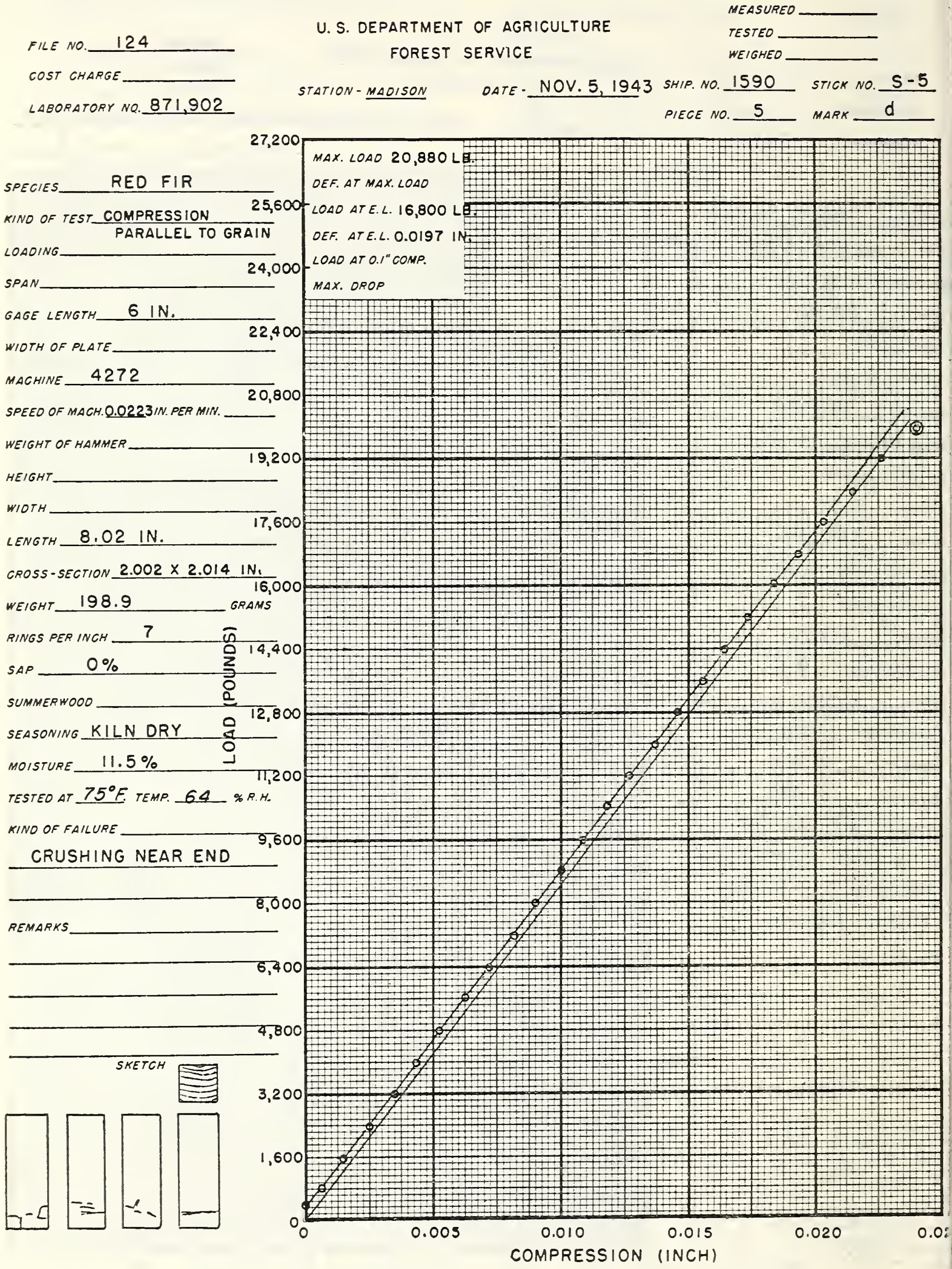
FILE NO. 124
COST CHARGE
LABORATORY NO. 100,831

STATION - MADISON
DATE - AUG. 24, 1914
SHIP. NO. L-315
STICK NO. S-8
PIECE NO. 4
MARK d

SPECIES DOUGLAS-FIR
KIND OF TEST STATIC BENDING
LOADING CENTER
SPAN 28 IN.
GAGE LENGTH
WIDTH OF PLATE
MACHINE M 1037
SPEED OF MACH. 0.105 IN. PER MIN.
WEIGHT OF HAMMER
HEIGHT 2.02 IN.
WIDTH 2.00 IN.
LENGTH 30.10 IN.
CROSS-SECTION
WEIGHT 1,251 GRAMS
RINGS PER INCH 9
SAP 0%
SUMMERWOOD 40%
SEASONING GREEN
MOISTURE 31.4%
TESTED AT 75°F. TEMP. 64 % R.H.
KIND OF FAILURE COMPRESSION FOLLOWED BY SPLINTERING TENSION.
REMARKS

MAX. LOAD 1,575 LB.
DEF. AT MAX. LOAD 0.66 IN.
LOAD AT E.L. 1,050 LB.
DEF. AT E.L. 0.199 IN.
LOAD AT 0.1" COMP.
MAX. DROP

Fig. 31.—Sample Data Sheet for Static Bending Test.



U. S. DEPARTMENT OF AGRICULTURE
FOREST SERVICE

MEASURED
TESTED
WEIGHED

FILE NO. 124
COST CHARGE
LABORATORY NO. 871,902

STATION - MADISON
DATE - NOV. 5, 1943
SHIP. NO. 1590
STICK NO. S-5
PIECE NO. 5
MARK d

SPECIES RED FIR
KIND OF TEST COMPRESSION PARALLEL TO GRAIN
LOADING
SPAN
GAGE LENGTH 6 IN.
WIDTH OF PLATE
MACHINE 4272
SPEED OF MACH. 0.0223 IN. PER MIN.
WEIGHT OF HAMMER
HEIGHT
WIDTH
LENGTH 8.02 IN.
CROSS-SECTION 2.002 X 2.014 IN.
WEIGHT 198.9 GRAMS
RINGS PER INCH 7
SAP 0%
SUMMERWOOD
SEASONING KILN DRY
MOISTURE 11.5%
TESTED AT 75°F. TEMP. 64 % R.H.
KIND OF FAILURE CRUSHING NEAR END
REMARKS

MAX. LOAD 20,880 LB.
DEF. AT MAX. LOAD
LOAD AT E.L. 16,800 LB.
DEF. AT E.L. 0.0197 IN.
LOAD AT 0.1" COMP.
MAX. DROP

FIG. 32.—Sample Data Sheet for Compression-Parallel-to-Grain Test.

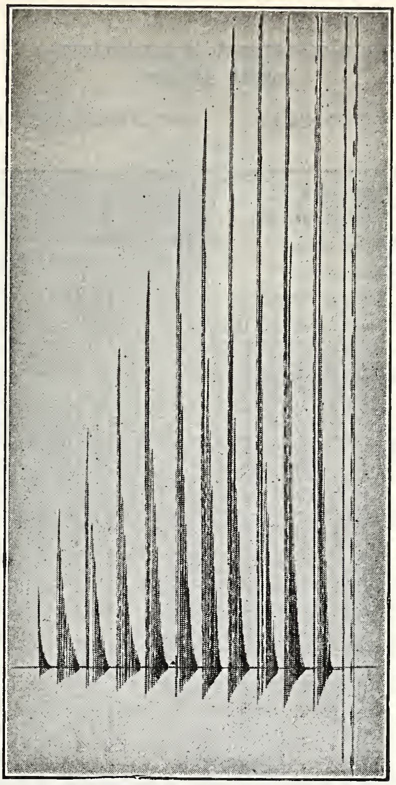
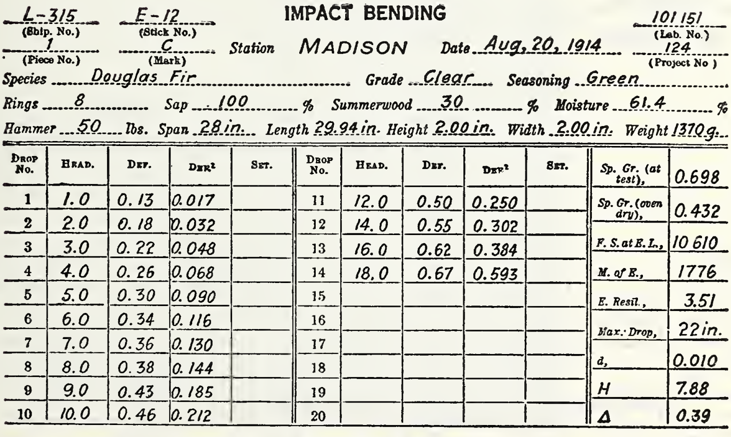


FIG. 33.—Sample Drum Record of Impact Bending Test.



IMPACT BENDING

L-315 (Ship. No.) E-12 (Stick No.) 101 151 (Lab. No.)

1 (Piece No.) C (Mark) Station MADISON Date Aug. 20, 1914 124 (Project No)

Species Douglas Fir Grade Clear Seasoning Green

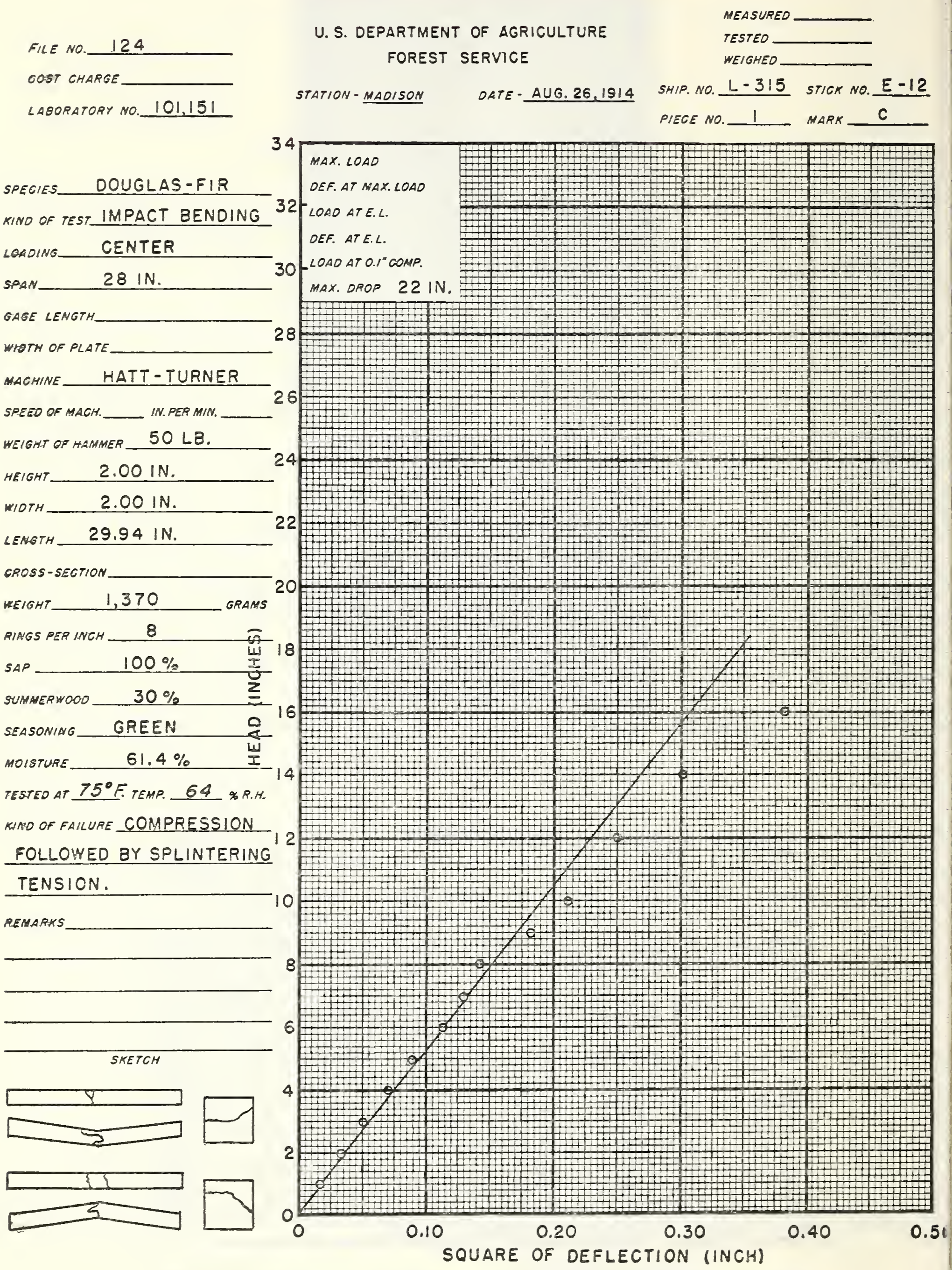
Rings 8 Sap 100 % Summerwood 30 % Moisture 61.4 %

Hammer 50 lbs. Span 28 in. Length 29.94 in. Height 2.00 in. Width 2.00 in. Weight 1370 g.

DROP No.	HEAD.	DEF.	DEF^2	SET.	DROP No.	HEAD.	DEF.	DEF^2	SET.		
1	1.0	0.13	0.017		11	12.0	0.50	0.250		Sp. Gr. (at test),	0.698
2	2.0	0.18	0.032		12	14.0	0.55	0.302		Sp. Gr. (oven dry),	0.432
3	3.0	0.22	0.048		13	16.0	0.62	0.384		F. S. at E. L.,	10 610
4	4.0	0.26	0.068		14	18.0	0.67	0.593		M. of E.,	1776
5	5.0	0.30	0.090		15					E. Resil.,	3.51
6	6.0	0.34	0.116		16					Max. Drop,	22 in.
7	7.0	0.36	0.130		17						
8	8.0	0.38	0.144		18					d,	0.010
9	9.0	0.43	0.185		19					H	7.88
10	10.0	0.46	0.212		20					Δ	0.39

Failure: Compression Followed by Splintering Tension.

FIG. 34.—Sample Data and Computation Card for Impact Bending Test.



FILE NO. 124

COST CHARGE

LABORATORY NO. 101,151

U. S. DEPARTMENT OF AGRICULTURE
FOREST SERVICE

MEASURED

TESTED

WEIGHED

STATION - MADISON

DATE - AUG. 26, 1914

SHIP. NO. L-315

STICK NO. E-12

PIECE NO. 1

MARK C

SPECIES DOUGLAS-FIR

KIND OF TEST IMPACT BENDING

LOADING CENTER

SPAN 28 IN.

GAGE LENGTH

WIDTH OF PLATE

MACHINE HATT-TURNER

SPEED OF MACH. IN. PER MIN.

WEIGHT OF HAMMER 50 LB.

HEIGHT 2.00 IN.

WIDTH 2.00 IN.

LENGTH 29.94 IN.

CROSS-SECTION

WEIGHT 1,370 GRAMS

RINGS PER INCH 8

SAP 100 %

SUMMERWOOD 30 %

SEASONING GREEN

MOISTURE 61.4 %

TESTED AT 75°F. TEMP. 64 % R.H.

KIND OF FAILURE COMPRESSION FOLLOWED BY SPLINTERING TENSION.

REMARKS

SKETCH

MAX. LOAD

DEF. AT MAX. LOAD

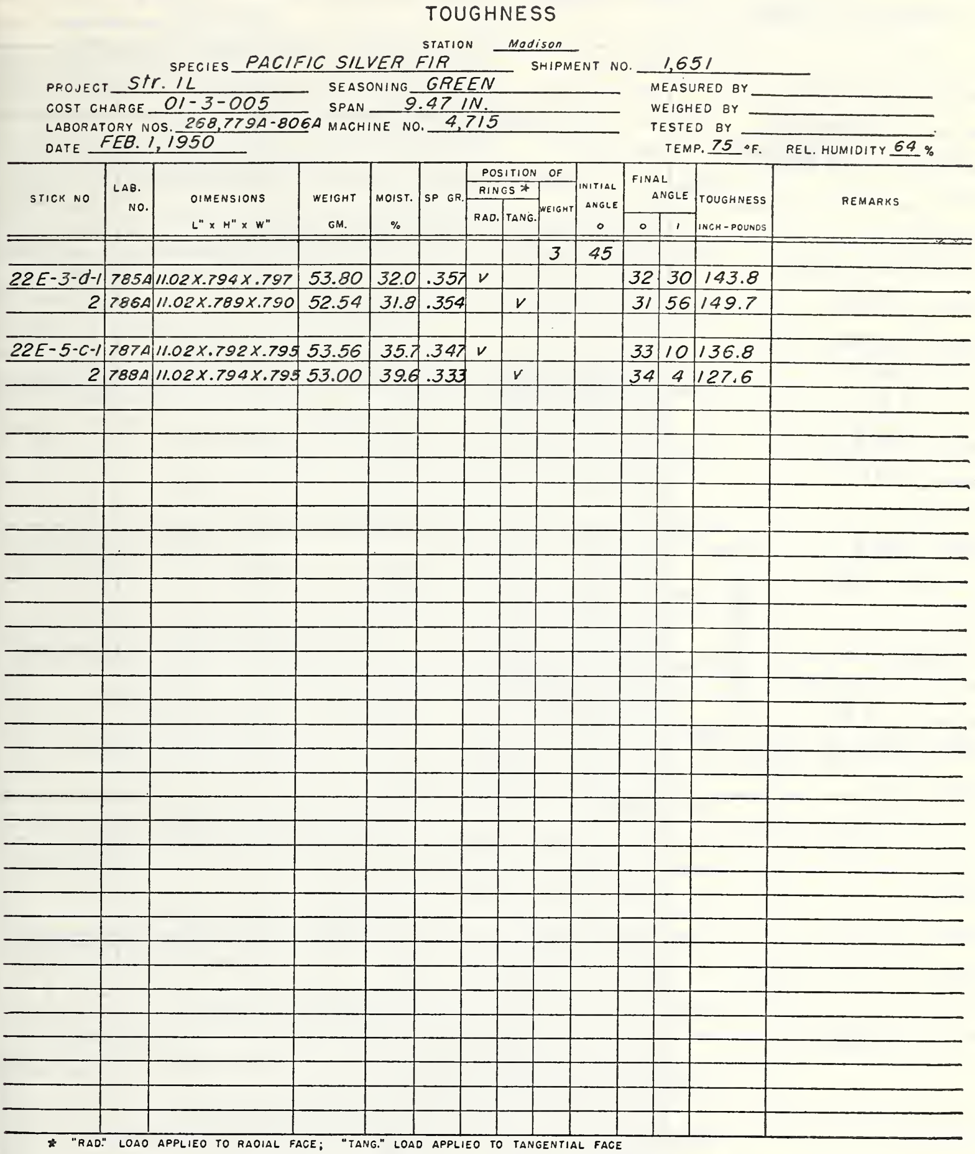
LOAD AT E.L.

DEF. AT E.L.

LOAD AT 0.1" COMP.

MAX. DROP 22 IN.

Fig. 35.—Sample Data Sheet for Impact Bending Test.



TOUGHNESS

STATION Madison

SPECIES PACIFIC SILVER FIR SHIPMENT NO. 1,651

PROJECT Str. IL
COST CHARGE 01-3-005
LABORATORY NOS. 268,779A-806A
DATE FEB. 1, 1950

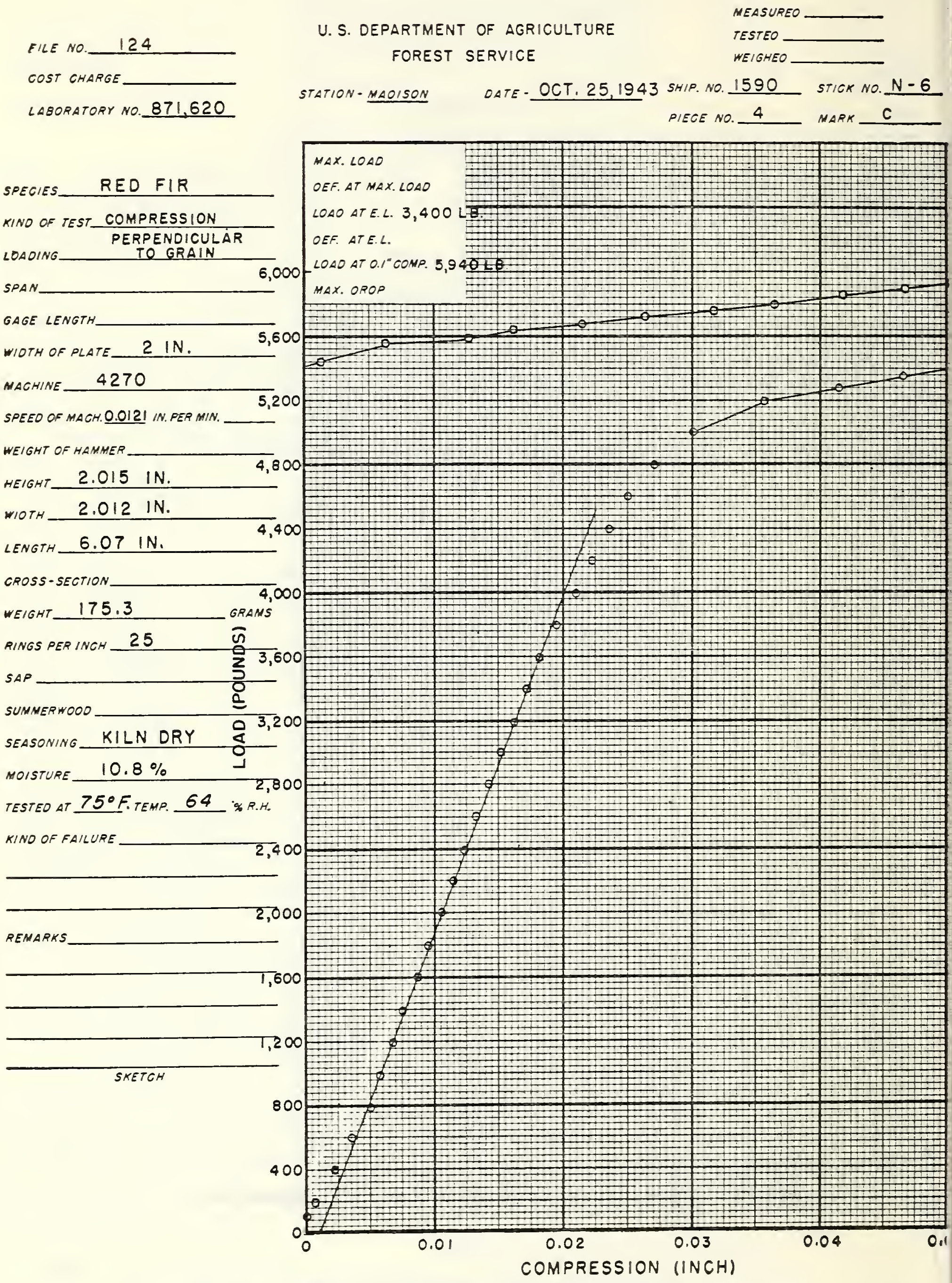
SEASONING GREEN
SPAN 9.47 IN.
MACHINE NO. 4,715

MEASURED BY
WEIGHED BY
TESTED BY
TEMP. 75 °F. REL. HUMIDITY 64 %

STICK NO	LAB. NO.	DIMENSIONS L" x H" x W"	WEIGHT GM.	MOIST. %	SP GR.	POSITION OF RINGS *		WEIGHT	INITIAL ANGLE °	FINAL ANGLE		TOUGHNESS INCH-POUNDS	REMARKS
						RAD.	TANG.			°	'		
								3	45				
22E-3-d-1	785A	11.02X.794X.797	53.80	32.0	.357	V				32	30	143.8	
2	786A	11.02X.789X.790	52.54	31.8	.354		V			31	56	149.7	
22E-5-c-1	787A	11.02X.792X.795	53.56	35.7	.347	V				33	10	136.8	
2	788A	11.02X.794X.795	53.00	39.6	.333		V			34	4	127.6	

* "RAD." LOAD APPLIED TO RADIAL FACE; "TANG." LOAD APPLIED TO TANGENTIAL FACE

FIG. 36.—Sample Data and Computation Sheet for Toughness Test.



U. S. DEPARTMENT OF AGRICULTURE
FOREST SERVICE

MEASURED ______
TESTED ______
WEIGHED ______

FILE NO. 124
COST CHARGE ______
LABORATORY NO. 871,620

STATION - MADISON
DATE - OCT. 25, 1943
SHIP. NO. 1590
STICK NO. N-6
PIECE NO. 4
MARK C

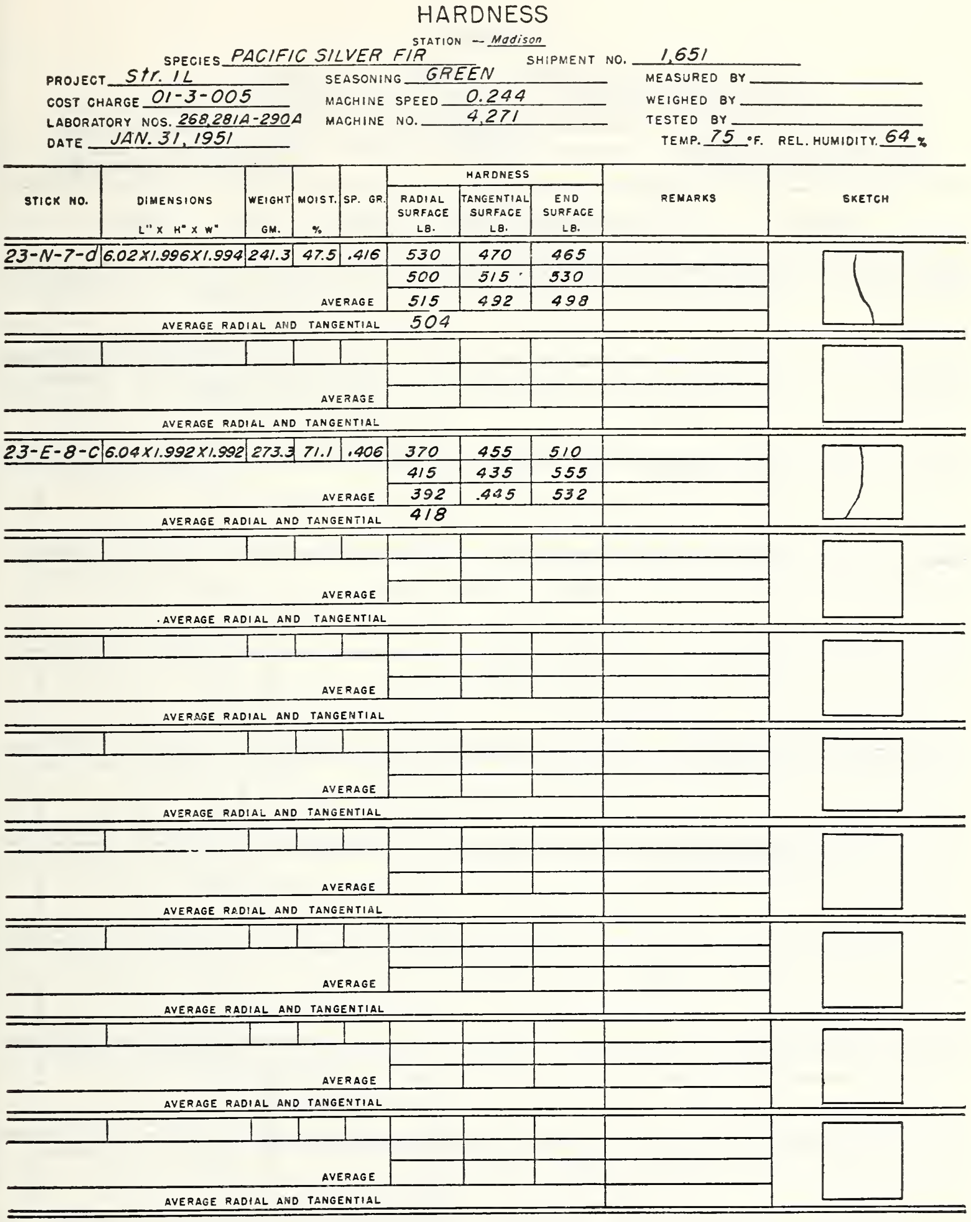
SPECIES RED FIR
KIND OF TEST COMPRESSION
LOADING PERPENDICULAR TO GRAIN
SPAN ______
GAGE LENGTH ______
WIDTH OF PLATE 2 IN.
MACHINE 4270
SPEED OF MACH. 0.0121 IN. PER MIN.
WEIGHT OF HAMMER ______
HEIGHT 2.015 IN.
WIDTH 2.012 IN.
LENGTH 6.07 IN.
CROSS-SECTION ______
WEIGHT 175.3 GRAMS
RINGS PER INCH 25
SAP ______
SUMMERWOOD ______
SEASONING KILN DRY
MOISTURE 10.8 %
TESTED AT 75°F. TEMP. 64 % R.H.
KIND OF FAILURE ______

REMARKS ______

SKETCH

MAX. LOAD
DEF. AT MAX. LOAD
LOAD AT E.L. 3,400 LB.
DEF. AT E.L.
LOAD AT 0.1" COMP. 5,940 LB
MAX. DROP

FIG. 37.—Sample Data Sheet for Compression-Perpendicular-to-Grain Test.



HARDNESS

STATION — *Madison*

SPECIES *PACIFIC SILVER FIR* SHIPMENT NO. *1,651*

PROJECT *Str. IL* SEASONING *GREEN* MEASURED BY

COST CHARGE *01-3-005* MACHINE SPEED *0.244* WEIGHED BY

LABORATORY NOS. *268,281A-290A* MACHINE NO. *4,271* TESTED BY

DATE *JAN. 31, 1951* TEMP. *75* °F. REL. HUMIDITY *64* %

STICK NO.	DIMENSIONS L" X H" X W"	WEIGHT GM.	MOIST. %	SP. GR.	HARDNESS RADIAL SURFACE LB.	HARDNESS TANGENTIAL SURFACE LB.	HARDNESS END SURFACE LB.	REMARKS	SKETCH
23-N-7-d	6.02X1.996X1.994	241.3	47.5	.416	530	470	465		
					500	515	530		
				AVERAGE	515	492	498		
				AVERAGE RADIAL AND TANGENTIAL	504				
				AVERAGE					
				AVERAGE RADIAL AND TANGENTIAL					
23-E-8-C	6.04X1.992X1.992	273.3	71.1	.406	370	455	510		
					415	435	555		
				AVERAGE	392	.445	532		
				AVERAGE RADIAL AND TANGENTIAL	418				
				AVERAGE					
				AVERAGE RADIAL AND TANGENTIAL					
				AVERAGE					
				AVERAGE RADIAL AND TANGENTIAL					
				AVERAGE					
				AVERAGE RADIAL AND TANGENTIAL					
				AVERAGE					
				AVERAGE RADIAL AND TANGENTIAL					
				AVERAGE					
				AVERAGE RADIAL AND TANGENTIAL					
				AVERAGE					
				AVERAGE RADIAL AND TANGENTIAL					
				AVERAGE					
				AVERAGE RADIAL AND TANGENTIAL					

FIG. 38.—Sample Data and Computation Sheet for Hardness Test.

SHEAR

STATION - *Madison*

SPECIES *PACIFIC SILVER FIR* SHIPMENT NO. *1,651*

PROJECT *Str. IL* SEASONING *GREEN* MEASURED BY

COST CHARGE *01-3-005* MACHINE SPEED *0.0215* WEIGHED BY

LABORATORY NOS. *267,024A-029A* MACHINE NO. *4,271* TESTED BY

DATE *JAN. 16, 1951* TEMP. *75* °F. REL. HUMIDITY *64* %

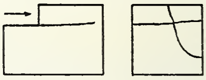
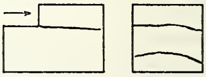
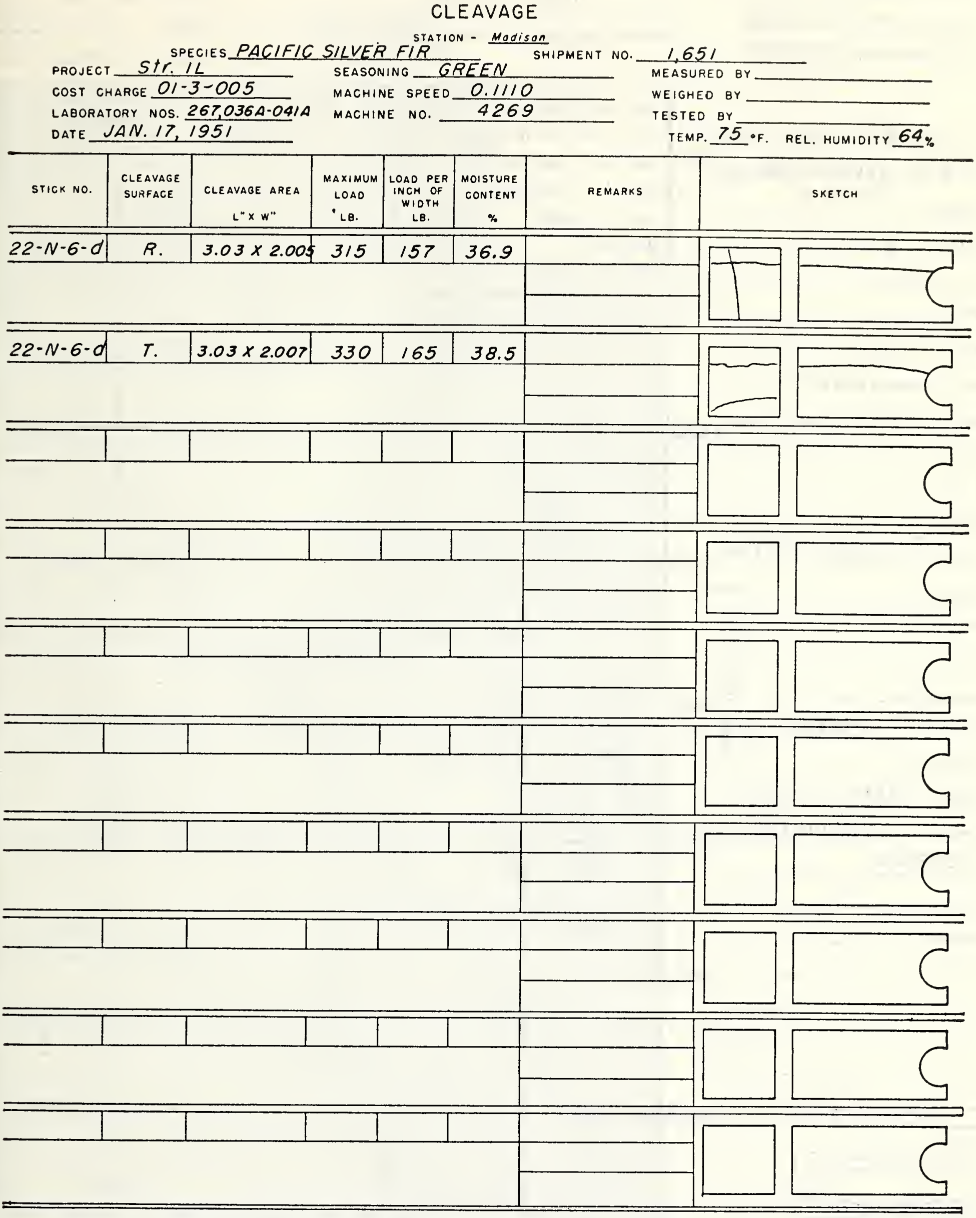
STICK NO.	SHEARING SURFACE	SHEARING AREA L" X W"	MAXIMUM LOAD LB.	SHEARING STRENGTH P.S.I.	MOISTURE CONTENT %	REMARKS	SKETCH
22-N-2-d	*R.*	*2.016 x 2.000*	*2770*	*687*	*40.1*		
22-N-6-d	*T.*	*2.020 x 1.998*	*2775*	*688*	*41.1*		

FIG. 39.—Sample Data and Computation Sheet for Shear-Parallel-to-Grain Test.



CLEAVAGE

STATION - Madison

SPECIES PACIFIC SILVER FIR

SHIPMENT NO. 1,651

PROJECT Str. IL

COST CHARGE 01-3-005

LABORATORY NOS. 267,036A-041A

DATE JAN. 17, 1951

SEASONING GREEN

MACHINE SPEED 0.1110

MACHINE NO. 4269

MEASURED BY

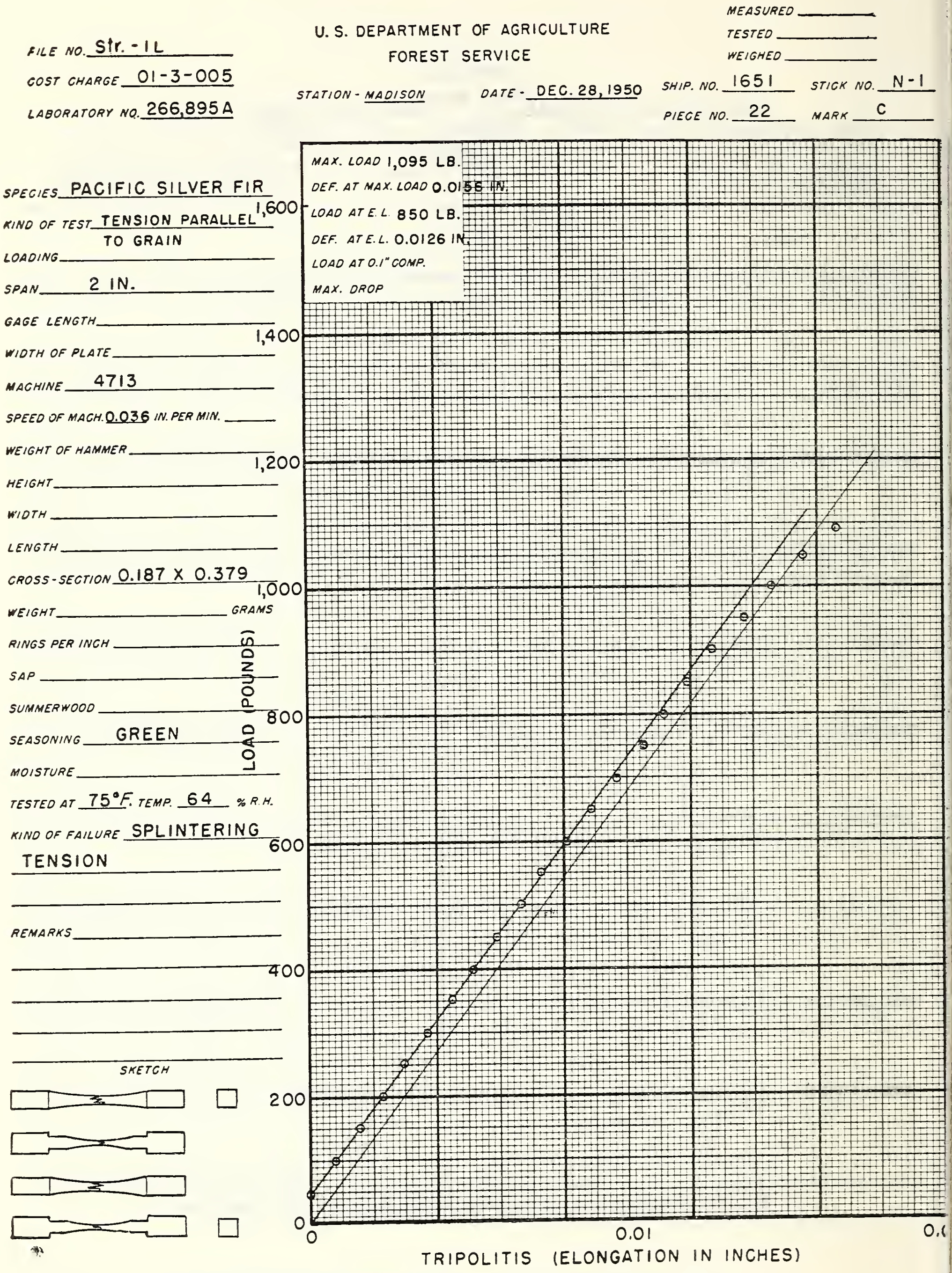
WEIGHED BY

TESTED BY

TEMP. 75 °F. REL. HUMIDITY 64%

STICK NO.	CLEAVAGE SURFACE	CLEAVAGE AREA L" X W"	MAXIMUM LOAD LB.	LOAD PER INCH OF WIDTH LB.	MOISTURE CONTENT %	REMARKS	SKETCH
22-N-6-d	R.	3.03 X 2.005	315	157	36.9		
22-N-6-d	T.	3.03 X 2.007	330	165	38.5		

FIG. 40.—Sample Data and Computation Sheet for Cleavage Test.



MEASURED
TESTED
WEIGHED

U. S. DEPARTMENT OF AGRICULTURE
FOREST SERVICE

FILE NO. Str. - IL
COST CHARGE 01-3-005
LABORATORY NO. 266,895 A

STATION - MADISON
DATE - DEC. 28, 1950
SHIP. NO. 1651
STICK NO. N-1
PIECE NO. 22
MARK C

SPECIES PACIFIC SILVER FIR
KIND OF TEST TENSION PARALLEL TO GRAIN
LOADING
SPAN 2 IN.
GAGE LENGTH
WIDTH OF PLATE
MACHINE 4713
SPEED OF MACH. 0.036 IN. PER MIN.
WEIGHT OF HAMMER
HEIGHT
WIDTH
LENGTH
CROSS-SECTION 0.187 X 0.379
WEIGHT GRAMS
RINGS PER INCH
SAP
SUMMERWOOD
SEASONING GREEN
MOISTURE
TESTED AT 75°F. TEMP. 64 % R.H.
KIND OF FAILURE SPLINTERING TENSION

REMARKS

SKETCH

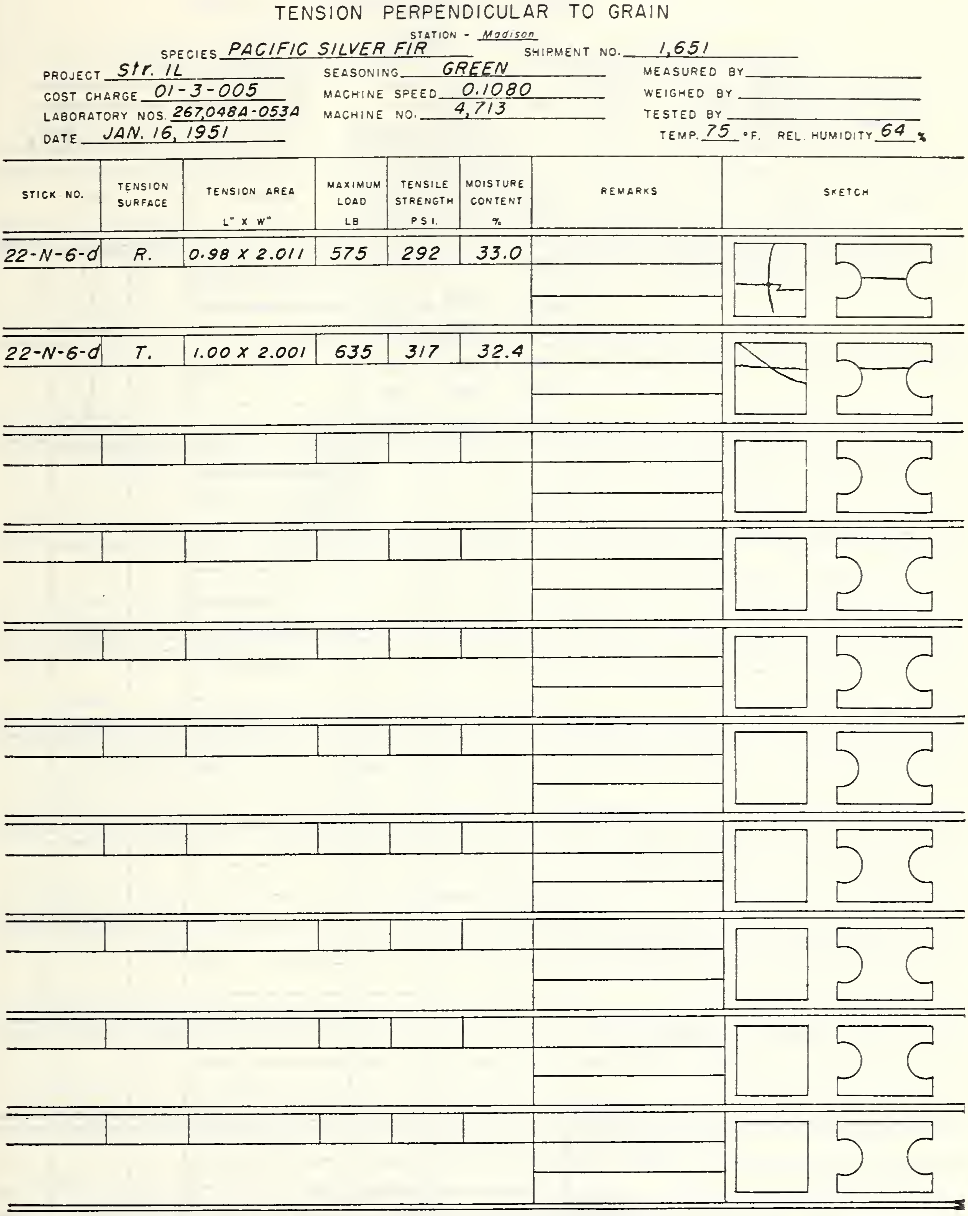
☐

☐

MAX. LOAD 1,095 LB.
DEF. AT MAX. LOAD 0.0156 IN.
LOAD AT E.L. 850 LB.
DEF. AT E.L. 0.0126 IN.
LOAD AT 0.1" COMP.
MAX. DROP

Fig. 41.—Sample Data Sheet for Tension-Parallel-to-Grain Test.

14-17



TENSION PERPENDICULAR TO GRAIN

STATION - Madison

SPECIES PACIFIC SILVER FIR

SHIPMENT NO. 1,651

PROJECT Str. IL

COST CHARGE 01-3-005

LABORATORY NOS. 267,048A-053A

DATE JAN. 16, 1951

SEASONING GREEN

MACHINE SPEED 0.1080

MACHINE NO. 4,713

MEASURED BY

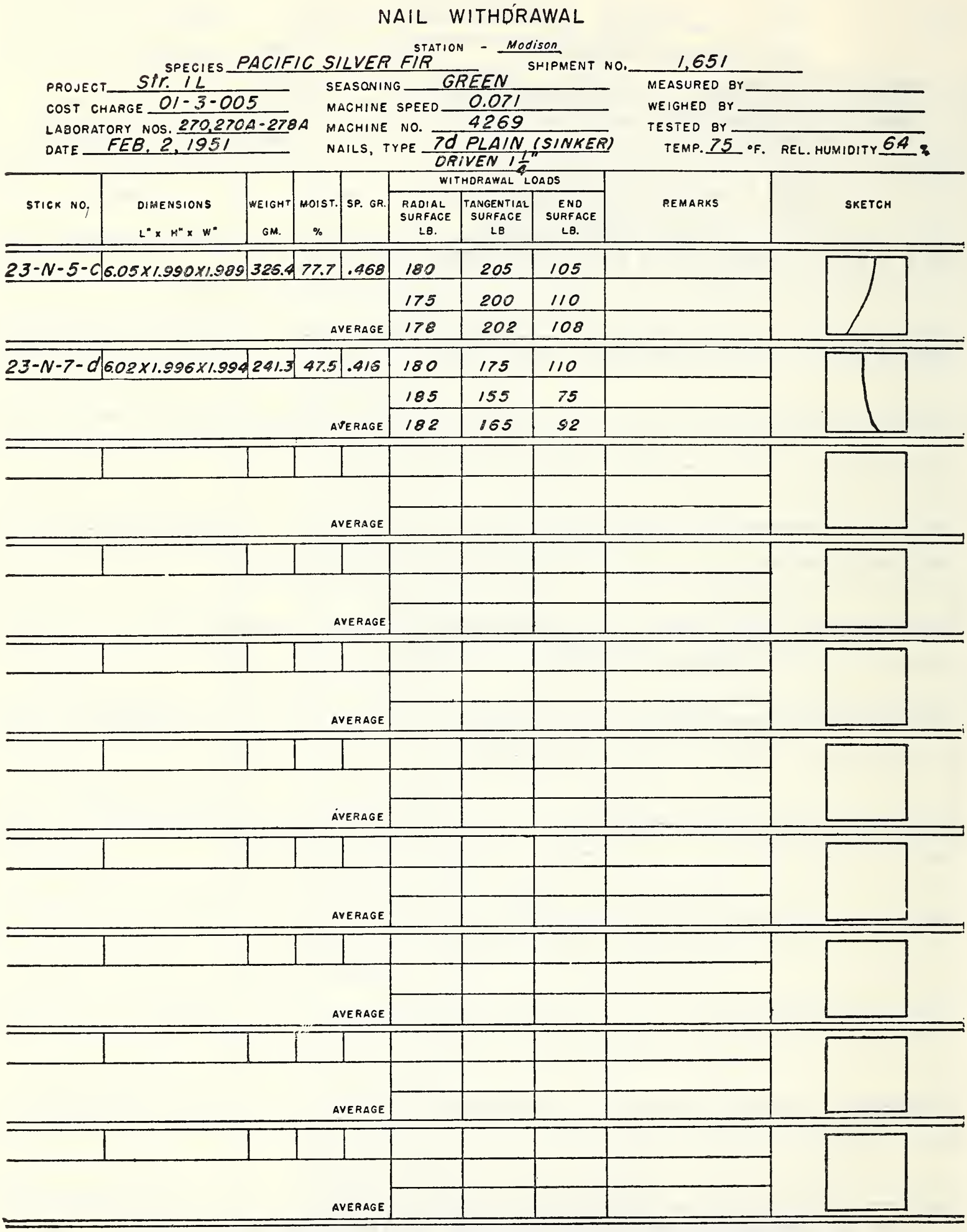
WEIGHED BY

TESTED BY

TEMP. 75 °F. REL. HUMIDITY 64 %

STICK NO.	TENSION SURFACE	TENSION AREA L" X W"	MAXIMUM LOAD LB	TENSILE STRENGTH P.S.I.	MOISTURE CONTENT %	REMARKS	SKETCH
22-N-6-d	R.	0.98 X 2.011	575	292	33.0		
22-N-6-d	T.	1.00 X 2.001	635	317	32.4		

Fig. 42.—Sample Data and Computation Sheet for Tension-Perpendicular-to-Grain Test.



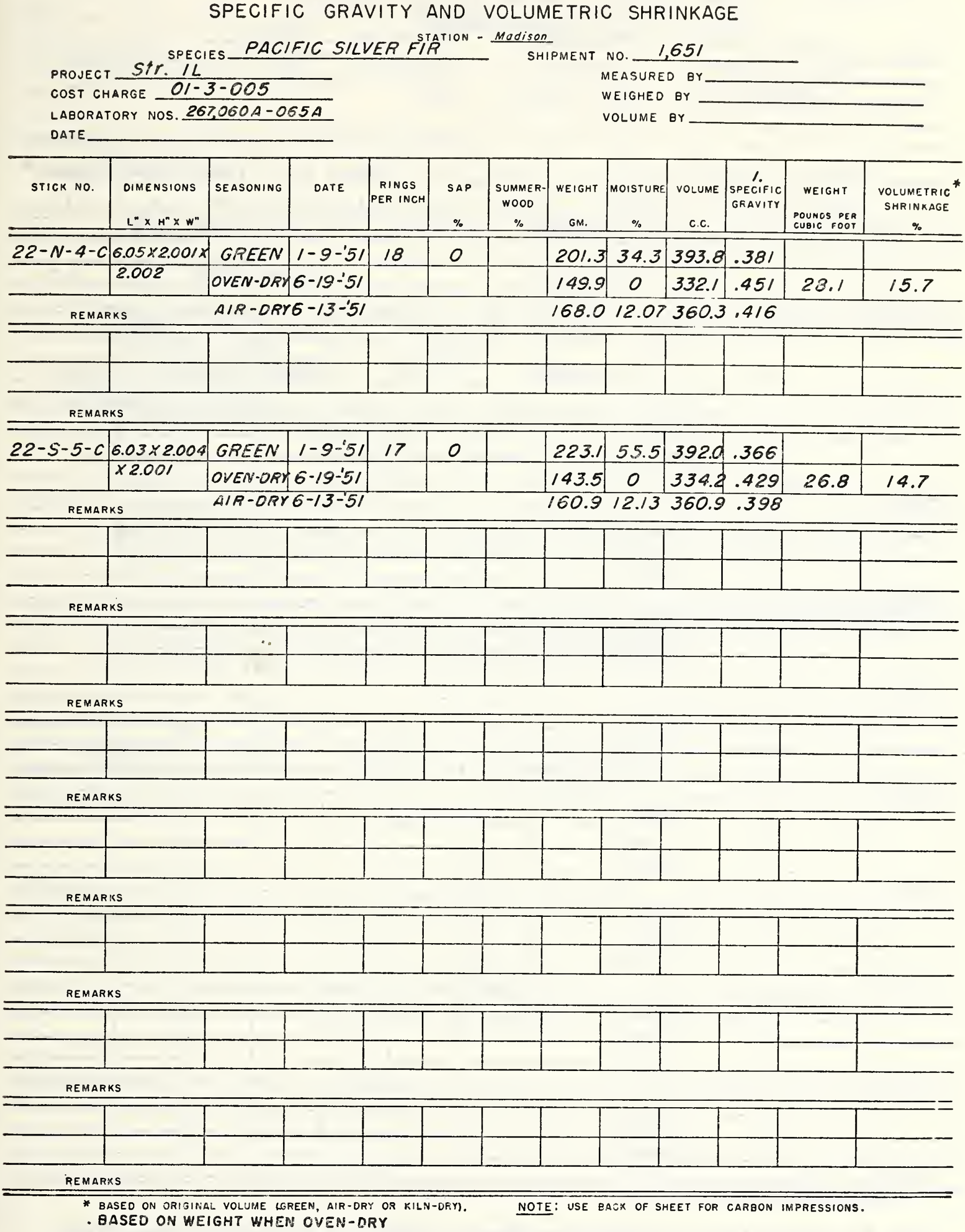
NAIL WITHDRAWAL

STATION - Modison

SPECIES PACIFIC SILVER FIR
SHIPMENT NO. 1,651
PROJECT Str. 1L
SEASONING GREEN
MEASURED BY
COST CHARGE 01-3-005
MACHINE SPEED 0.071
WEIGHED BY
LABORATORY NOS. 270,270A-278A
MACHINE NO. 4269
TESTED BY
DATE FEB. 2, 1951
NAILS, TYPE 7d PLAIN (SINKER) DRIVEN $1\frac{1}{4}$"
TEMP. 75 °F. REL. HUMIDITY 64 %

STICK NO.	DIMENSIONS L" x H" x W"	WEIGHT GM.	MOIST. %	SP. GR.	WITHDRAWAL LOADS			REMARKS	SKETCH
					RADIAL SURFACE LB.	TANGENTIAL SURFACE LB	END SURFACE LB.		
23-N-5-C	6.05X1.990X1.989	326.4	77.7	.468	180	205	105		
					175	200	110		
				AVERAGE	178	202	108		
23-N-7-d	6.02X1.996X1.994	241.3	47.5	.416	180	175	110		
					185	155	75		
				AVERAGE	182	165	92		
				AVERAGE					
				AVERAGE					
				AVERAGE					
				AVERAGE					
				AVERAGE					
				AVERAGE					
				AVERAGE					
				AVERAGE					

FIG. 43.—Sample Data and Computation Sheet for Nail Withdrawal Test.



SPECIFIC GRAVITY AND VOLUMETRIC SHRINKAGE

STATION - *Madison*

SPECIES *PACIFIC SILVER FIR*

SHIPMENT NO. *1,651*

PROJECT *Str. IL*

COST CHARGE *01-3-005*

LABORATORY NOS. *267,060A-065A*

DATE

MEASURED BY

WEIGHED BY

VOLUME BY

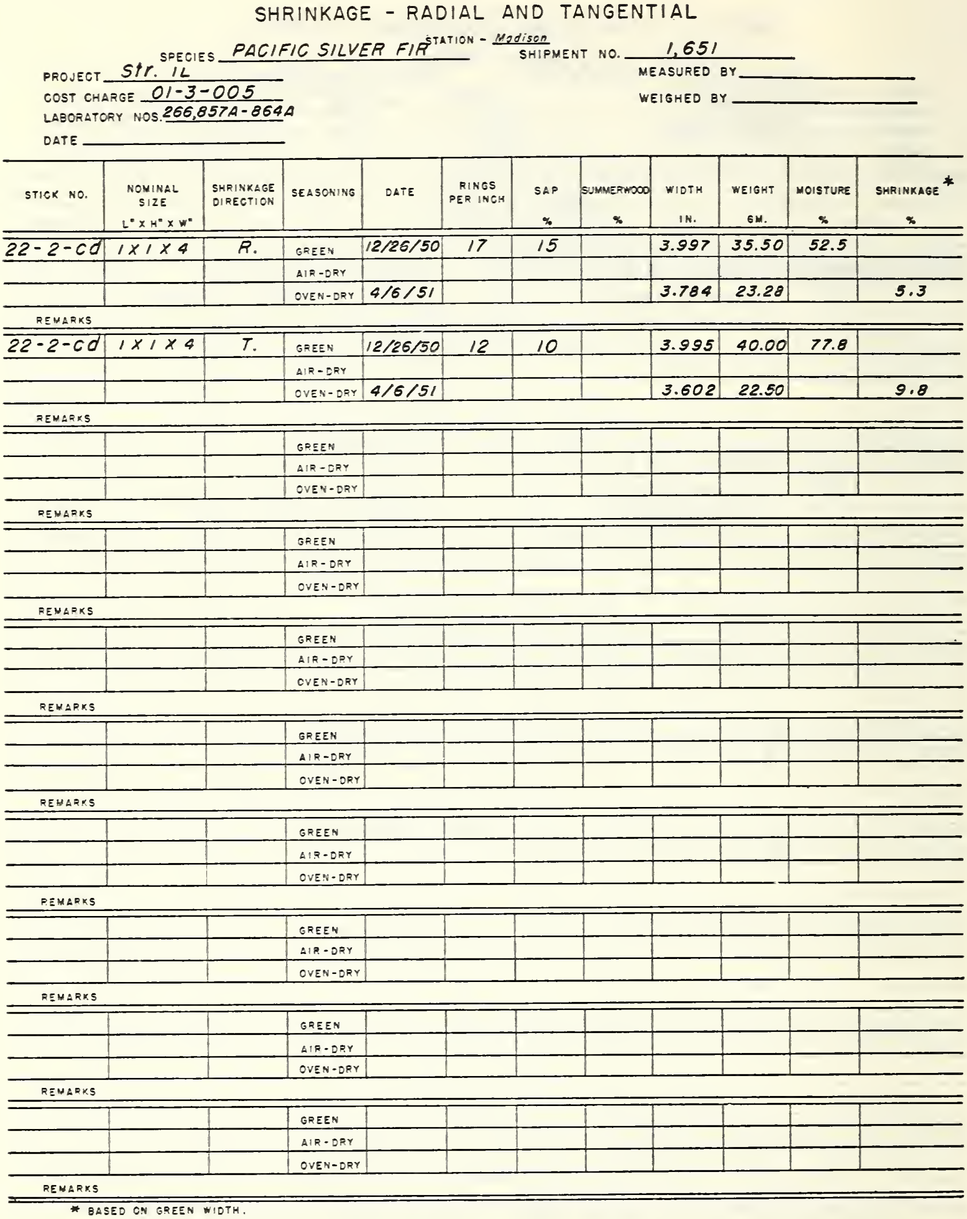
STICK NO.	DIMENSIONS L" x H" x W"	SEASONING	DATE	RINGS PER INCH	SAP %	SUMMER-WOOD %	WEIGHT GM.	MOISTURE %	VOLUME C.C.	/. SPECIFIC GRAVITY	WEIGHT POUNDS PER CUBIC FOOT	VOLUMETRIC* SHRINKAGE %
22-N-4-C	6.05X2.001X	GREEN	1-9-'51	18	0		201.3	34.3	393.8	.381		
	2.002	OVEN-DRY	6-19-'51				149.9	0	332.1	.451	28.1	15.7
REMARKS		AIR-DRY	6-13-'51				168.0	12.07	360.3	.416		
REMARKS												
22-S-5-C	6.03X2.004	GREEN	1-9-'51	17	0		223.1	55.5	392.0	.366		
	X2.001	OVEN-DRY	6-19-'51				143.5	0	334.2	.429	26.8	14.7
REMARKS		AIR-DRY	6-13-'51				160.9	12.13	360.9	.398		
REMARKS												
REMARKS												
REMARKS												
REMARKS												
REMARKS												
REMARKS												
REMARKS												

* BASED ON ORIGINAL VOLUME (GREEN, AIR-DRY OR KILN-DRY).

. BASED ON WEIGHT WHEN OVEN-DRY

NOTE: USE BACK OF SHEET FOR CARBON IMPRESSIONS.

Fig. 44.—Sample Data and Computation Sheet for Specific Gravity and Shrinkage-in-Volume Test.



SHRINKAGE - RADIAL AND TANGENTIAL

SPECIES PACIFIC SILVER FIR
STATION - Madison
SHIPMENT NO. 1,651
PROJECT Str. IL
MEASURED BY
COST CHARGE 01-3-005
WEIGHED BY
LABORATORY NOS. 266,857A-864A
DATE

STICK NO.	NOMINAL SIZE L" X H" X W"	SHRINKAGE DIRECTION	SEASONING	DATE	RINGS PER INCH	SAP %	SUMMERWOOD %	WIDTH IN.	WEIGHT GM.	MOISTURE %	SHRINKAGE* %
22-2-cd	1 X 1 X 4	R.	GREEN	12/26/50	17	15		3.997	35.50	52.5	
			AIR-DRY								
			OVEN-DRY	4/6/51				3.784	23.28		5.3
REMARKS											
22-2-cd	1 X 1 X 4	T.	GREEN	12/26/50	12	10		3.995	40.00	77.8	
			AIR-DRY								
			OVEN-DRY	4/6/51				3.602	22.50		9.8
REMARKS											
			GREEN								
			AIR-DRY								
			OVEN-DRY								
REMARKS											
			GREEN								
			AIR-DRY								
			OVEN-DRY								
REMARKS											
			GREEN								
			AIR-DRY								
			OVEN-DRY								
REMARKS											
			GREEN								
			AIR-DRY								
			OVEN-DRY								
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REMARKS											
			GREEN								
			AIR-DRY								
			OVEN-DRY								
REMARKS											
			GREEN								
			AIR-DRY								
			OVEN-DRY								
REMARKS											

* BASED ON GREEN WIDTH.

FIG. 45.—Sample Data and Computation Sheet for Radial- and Tangential-Shrinkage Tests.

Ship. Descr. 1

TABLE I.—SHIPMENT DESCRIPTION—FIELD NOTES.

Date *Sept. 1946*
Shipment No. *1625* Species *Douglas-fir* Project No. *259*
State *Oregon* County *Lane*
Local contact: National Forest *Willamette* Private owner ———
Name ———————— Address *Eugene, Oregon*

A. General ecological description of locality:*
  1. Climatic factors:
    a. Precipitation in inches: average annual amount *38.4* ; seasonal distribution—spring *9.4* , summer *2.5* , autumn *10.5* , winter *16.0*
    b. Temperature, degrees Fahrenheit: mean annual *52* , mean summer *64* mean winter *41* , maximum summer *99* , minimum winter *−3*
      Season between killing frosts: (dates) *Oct. 31* to *April 17*
    c. Relative humidity: high, medium, or low in spring *high* summer, *low* , autumn *high* , winter *high*
    d. Prevailing wind direction: *Westerly;* summer ______ winter ______
  2. Topographic factors:
    a. Character of topography: level, rolling, *mountainous*, to *precipitous*
    b. Elevations: absolute *3,000 ft.* , relative *2,000 to 4,000 ft.*
    c. Presence of streams, lakes, swamps: numerous, *few*, *permanent*, intermittent *(Salt Creek Valley)*
    d. Geological history—original rock formations: (1) *igneous*, (2) sedimentary—shales, sandstones, limestones
      Secondary formations: *local*, glacial, alluvial, loessal *from basalt or tuffaceous conglomerate. The soils are mainly derived from weathered consolidated rocks. Stones and boulders are abundant over the surface and embedded in soil material.*

---

* Prepare page 1 of this form for each shipment. Underline descriptive words and fill in all blank spaces that apply. Use reverse of this form for additional notes.

Ship. Descr. 2

TABLE I (*Continued*).

Date *Sept. 23–25, 1946*

Shipment No. *1625* Species *Douglas-fir* Project No. *259*

State *Oregon* Co. *Lane* Twp. *22S* Range *5E* Sec. *22*

Locate on *map* or sketch; *4* miles to *McCredie Springs, Oregon*

B. Site description.*

1. Site quality class: I, *II*, III, IV, V; or age *100 years*, height *170 ft.* of dominant trees
2. Physiography
   a. Elevation: absolute *3,000 ft.*, range over area *±50 ft.*
   b. Surface: level, undulating; *slope* ____, upper ____, *lower* *cove*, *degree* *15°*; ridge, valley bottom
   c. Aspect: N, NE, E, SE, S, *SW*, W, NW
   d. Distance to streams, lakes, swamps *Salt Creek—1/8 mile*
   e. Soil type: sand, sandy loam, *loam*, clay loam, clay
      U. S. Soil Survey name *Olympic Series*
      (1) Color *brown,* (2) *acid* or alkaline, (3) depth *3 to 6 ft.*
      (4) *boulders, stones*, or gravel *numerous*
   f. Soil moisture: dry, *moist*, wet, flooded.
      (1) Natural drainage: *good*, medium, poor
      (2) Depth of water table, —— feet

C. Forest description:

1. Origin: *natural*, artificial; *seed*, sprout, planted ____
2. History: fires, *lumbering;* wind, snow, sleet, tapping for exudates
   a. Year: *1941 to 1945* ___, ___, ___, *Some piling removed*
3. Pathological condition: *good*, medium, poor.
   a. Species attacked ——. Injury to trunk, branch, leaf, root ____
4. Type name *Douglas-fir*; all aged, *even aged* ____
   a.

Species	Percent	Age *Av.* or range	D.B.H. Av. or *range*
Douglas-fir	*100*	*100 years*	*12 to 48 in.*

   b. No. of trees over *10* in. d.b.h. per acre *100* (1/4 acre, 57 ft. radius; 1/8 acre, 41.7 ft. radius; 1/10 acre, 37.3 ft. radius).
   c. Density of crown cover: 0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 0.7, *0.8*, 0.9, 1.0.
   d. Underbrush: species *Vine maple*
      amount ____
5. Forest floor
   a. Ground cover: weeds, grass, *bracken*, briars, vines. *Sword fern, Salal brush.*
   b. Litter: kind *Dead needles and branches* amount *moderate*
   c. Raw humus or duff: depth *1 in.*
   d. Humus: depth *1/2 in.*
6. Photographs: *yes*, no. Taken by *A. K.*
7. Trees collected: *Nos. 1 to 10.*

---

* Prepare page 2 of this form for each site or forest. Underline descriptive words and fill in all blank spaces that apply. Use reverse of this form for additional notes.

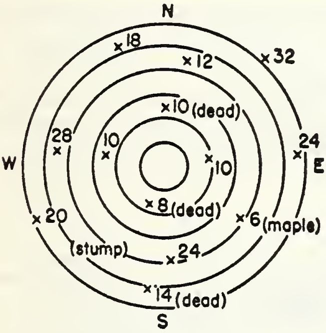
Ship. Descr. 3

TABLE I (*Continued*).

Shipment No. *1625* Species *Douglas-fir* Project No. *259*
State *Oregon* Co. *Lane* Twp. *22S* Range *5E* Sec. *22*

D. Tree description:* Tree No. *6*

1. Date sawed *Sept. 24, 1946* How removed from woods *Truck* Date *Oct. 9, 1946*
2. Tree class: Open, ***dominant***, codominant, intermediate, suppressed.
3. Origin: ***seedling***, sprout. 4. Age at stump *99* years.
5. D.B.H.o.b. *25* ***in.*** Total ht. *165* ft. Merch. l. *132* ft. Top d.i.b. *8 in.*
6. Stu ht. *24* in. Root swelling ht. *12* in. Av. diam. stump. i.b. *23* in.
7. Crown length *60* ft., width *30* ft., projection, ft. E. *20* W *10* N *15* S *15*
8. Foliage density: thick, ***medium***, thin.
9. Lean: direction ——— ; 2, 4, 6 ——— degrees. Crook: form,), (,
10. Locate position and size of adjacent trees and stumps on diagram of concentric circles assuming the tree to stand at the center and the intervals to be *5* (or 10) ft. Indicate d.b.h and species by appropriate abbreviations.



Legend:

All trees Douglas-fir except as indicated.

11. Give approximate time of cutting any adjacent trees *1941*
12. Photographs of standing tree *one*

E. Specimens shipped:

1. Herbarium material: leaves ———, fruit ———, flowers ———
2. Size of pieces and location in tree:

	Mark	Height above ground of lower end, ft.	Length, ft.	Diameters i. b., in.	
				Bottom	Top
First section	*128*	*2*	*20*	*23*	*20*
Second section	*129*	*22*	*20*	*20*	*19*
Third section	*130*	*58*	*24*	*18*	*15*
Fourth section	*131*	*106*	*12*	*12*	*10*

3. Defects: Kind ——— Extent ———
4. Photographs of sections ———

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* Prepare page 3 of this form for each tree. Underline descriptive words and fill in all blank spaces that apply. Use reverse of this form for additional notes.

Ship, Descr. FG

TABLE I (*Concluded*).

UNITED STATES DEPARTMENT OF AGRICULTURE
FOREST SERVICE
FG. Shipping, Routing, and Storing

Shipment No. *1625* Project No. *259*

Consisting of:

Species	No. of pieces	Species	No. of species
Douglas-fir (samples from 10 trees)	*40 logs*		

Date cut *Sept. 24–25, 1946*
In state of *Oregon* County *Lane* Township
Manufactured at Date
Shipped from *Oakridge, Oregon* Date *Oct. 17, 1946*
Via *Southern Pacific Railroad*
In car *CNJ* No. *89026*
Initial
Condition when shipped *Green; ends of logs painted*

Received at *Madison, Wisconsin* Date *Nov. 1, 1946*
Condition when received *Good*
How stored *On skids in yard.*
Records: Correspondence *Pacific Northwest Forest Experiment Station (Portland, Oregon)*

Photographs

Remarks

APPROVED AS
AMERICAN STANDARD
BY THE AMERICAN STANDARDS ASSOCIATION
ASA NO.: 07.1-1958
UDC 674.243:620.17

Standard Methods of

TESTING VENEER, PLYWOOD, AND OTHER GLUED VENEER CONSTRUCTIONS[1]

ASTM Designation: D 805-52

ADOPTED, 1947; REVISED, 1952.[2]

Reapproved in 1958 Without Change.

This Standard of the American Society for Testing Materials is issued under the fixed designation D 805; the final number indicates the year of original adoption as standard or, in the case of revision, the year of last revision.

The expanding use of plywood, wood, and wood-base laminated materials has stimulated an interest in the mechanical properties of these materials, and in methods for evaluating their mechanical properties. In the preparation of these methods of test, special consideration has been given to procedures already in satisfactory use in the determination of the mechanical and physical properties. Consideration has been given also to the correlation of the methods with related procedures already in use or under consideration for other materials.

The mechanical tests described in these methods may be made to obtain strength data for design purposes, to determine the effect on strength of various treatments or of various factors in processing, to ascertain properties in relation to the various grain or fiber directions of the material, to compare the properties of different base materials or different species, and for other similar purposes.

Scope

1. These methods cover procedures for determining the following properties of veneer, plywood, and other glued veneer constructions:

	Section
Compression	4 to 10
Static Bending	11 to 17
Tension	18 to 22
Panel Shear (Forest Products Laboratory Test)	23 to 30
Shearing Strength (Alternate Method Using Tension Type Shear Specimen)	31 to 36
Plate Shear (Forest Products Laboratory Test)	37 to 42
Toughness	43 to 48
Rockwell Hardness (For material with specific gravity equal to or greater than 1.0)	49 to 52
Swelling and Recovery of Compressed Wood Products Due to Moisture Absorption	53 to 57
Moisture Absorption of Compressed Wood Products	58 to 62
Glue Block Shear Test	63 to 67
Plywood Glue Shear Test	68 to 73
Moisture Content and Specific Gravity	74 and 75

Test Specimen

2. (*a*) *Selection of Test Specimens.*—The number of test specimens to be chosen for test and the method of their

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[1] Under the standardization procedure of the Society, these methods are under the jurisdiction of the ASTM Committee D-7 on Wood.

[2] Prior to adoption as standard, these methods were published as tentative from 1944 to 1947, being revised in 1945.

selection depend on the purpose of the particular tests under consideration, so that no general rule can be given to cover all instances. It is recommended that whenever possible, a sufficient number of tests be made to permit statistical treatment of the test data. In the evaluation of a material, specimens for test should be obtained from a representative number of sheets or panels. Specimens shall not be taken closer to the edge of the sheet or panel than twice the thickness of the sheet or panel.

(*b*) *Control of Moisture Content.*—The physical and mechanical properties of veneer, plywood, and other glued veneer constructions depend on the moisture content at time of test. Therefore, material for test in the dry condition shall preferably be conditioned to constant weight and moisture content in a conditioning chamber maintained at a relative humidity of 65 ± 1 per cent and a temperature of 20 ± 3 C (68 ± 6 F) (Note). Likewise, the tests when possible shall be made in a room maintained at like temperature and humidity conditions. If there is any departure from this recommended procedure it shall be so stated in the report.

NOTE.—In following the recommendation that the temperature be controlled to 20 ± 3 C (68 ± 6 F) it should be understood that it is desirable to maintain the temperature as nearly constant as possible at some temperature within this range.

Report

3. The report of each test shall include a complete description of the material. For plywood, the report shall include the species and thickness of each ply, the grain direction, the type of glue, the kind of veneer with respect to method of cutting, the pressing temperature, and the pressure for each panel. For other glued constructions, the report shall include the essential information on the base material, the method of treatment or impregnation, if any, the kind and amount of impregnating material used, the direction of the grain or fibers, the temperature and pressure used, and the thickness.

COMPRESSION

Direction of Grain or Fibers

4. The grain direction of the individual plies or laminations shall be parallel, perpendicular, or inclined at any other required angle to the length of the test specimen.

Types of Test

5. Two types of compression tests are provided, as follows:

(*a*) *Method A*, providing lateral support of the specimen when needed, shall be used when tests to evaluate both elastic and compressive strength properties are required.

(*b*) *Method B*, employing a specimen without lateral support, may alternatively be used when tests to evaluate maximum compressive strength only are required.

Test Specimen

6. (*a*) The test specimen shall be rectangular in cross-section. The thickness, width, and length of each specimen shall be measured to an accuracy of not less than ±0.3 per cent.

(*b*) When tests to evaluate both elastic and compressive strength properties are required (Method A), the size of the specimens shall be as follows:

(*1*) *For Material Over* $\frac{1}{4}$ *in.* (*6 mm*) *in Thickness*, the specimen shall have a thickness equal to that of the material and the width shall be a minimum of 1 in. (25 mm) but not less than the thickness. The length shall be not greater than seven times the least cross-sectional dimension.

(*2*) *For Material* $\frac{1}{4}$ *in.* (*6 mm*) *or Less in Thickness*, the specimen shall have a thickness equal to that of the material and the width shall be nominally 1 in. (25 mm). The length shall be 4 in. (10 cm). Such specimens shall be supported laterally throughout the test.

(*c*) When tests to evaluate maximum compressive strength only are required (Method B), an alternate type of specimen 4 in. (10 cm) in width, and with a length equal to six times the thickness may be used.

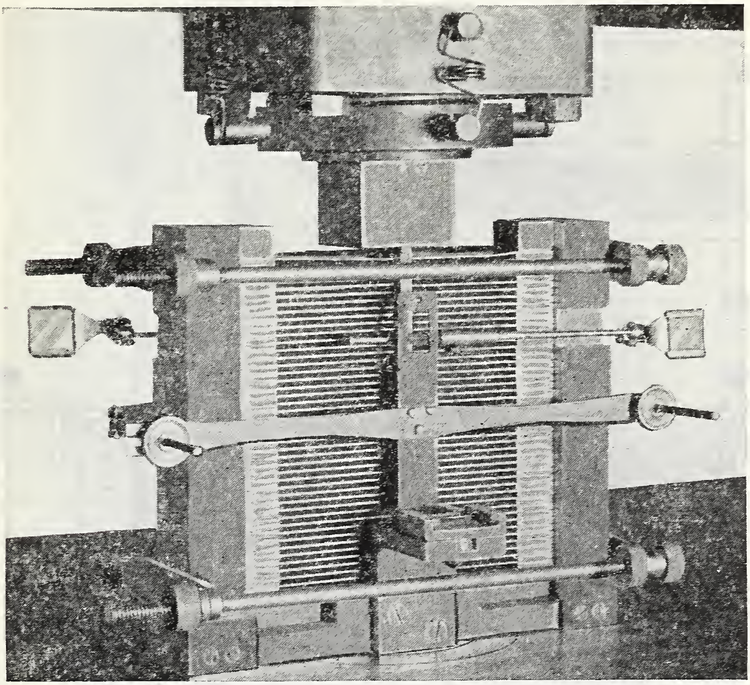


FIG. 1.—Compression Test of Thin Plywood Supported Laterally Showing Marten's Mirror Compressometer for Measuring Deformations on Two Opposite Faces.

End Surfaces Parallel

7. Care shall be taken in preparing the test specimens to make the end surfaces smooth and parallel to each other and at right angles to the length.

Method A, Evaluation of Both Maximum Crushing Strength and Elastic Properties

8. (*a*) Test specimens $\frac{1}{4}$ in. (6 mm) or less in thickness intended for use in obtaining load deformation data shall be supported laterally to prevent buckling during the test, but undue pressure shall not be exerted against the sides of the specimen. This support shall not measurably restrain the normal compressive deformation under load. A satisfactory method of providing lateral support is illustrated in Fig. 1, and a detailed design of this apparatus is shown in Fig. 2.

(*b*) *Loading Procedure.*—The load shall be applied through a spherical bearing block preferably of the suspended, self-aligning type. The load shall be applied with a continuous motion of the movable head to maximum load at a rate of 0.003 in. per in. (cm per cm) of length of the specimen per minute within a permissible variation of ±25 per cent.

(*c*) *Load-Deformation Curves.*—Data for load-deformation curves may be taken to determine the modulus of elas-

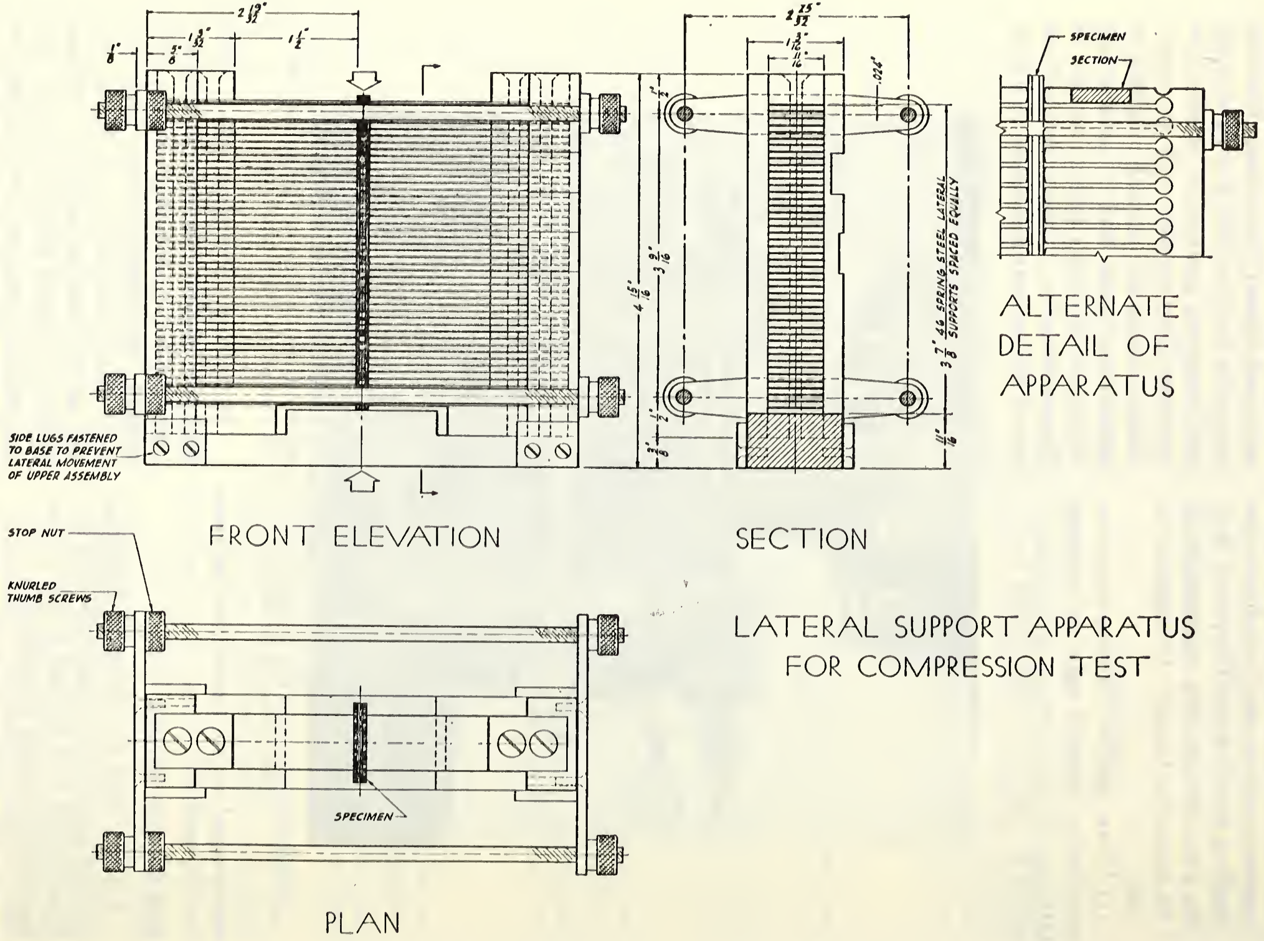

2 19/32"
1 3/32"
1 1/2"
1/8"
5/8"
SIDE LUGS FASTENED TO BASE TO PREVENT LATERAL MOVEMENT OF UPPER ASSEMBLY
FRONT ELEVATION
2 25/32"
1 3/16"
11/16"
.024"
1/2"
4 15/16"
3 9/16"
3 7/8" 46 SPRING STEEL LATERAL SUPPORTS SPACED EQUALLY
11/16"
3/8"
SECTION
SPECIMEN
SECTION
ALTERNATE DETAIL OF APPARATUS
STOP NUT
KNURLED THUMB SCREWS
SPECIMEN
PLAN
LATERAL SUPPORT APPARATUS FOR COMPRESSION TEST

FIG. 2.—Apparatus for Lateral Support for Compression Test.

ticity and the proportional limit. Increments of load shall be chosen so that not less than 12 and preferably 15 or more readings of load and deformation are taken to the proportional limit. The deformation shall be read to the nearest 0.0001 in. (0.002 mm). Compressometers shall be attached over the central portion of the length of the specimen and the points of attachment shall be not less than $\frac{3}{4}$ in. (18 mm) from the specimen ends. Fig. 3 shows a type of Lamb's roller compressometer, with a 2-in. (5-cm) gage length that has been found satisfactory for specimens $3\frac{1}{2}$ to 6 in. (9 to 16 cm) in length. A suitable arrangement of a Marten's mirror having a 2-in. (5-cm) gage lenth for measuring deformations of laterally supported specimens is illustrated in Fig. 1.

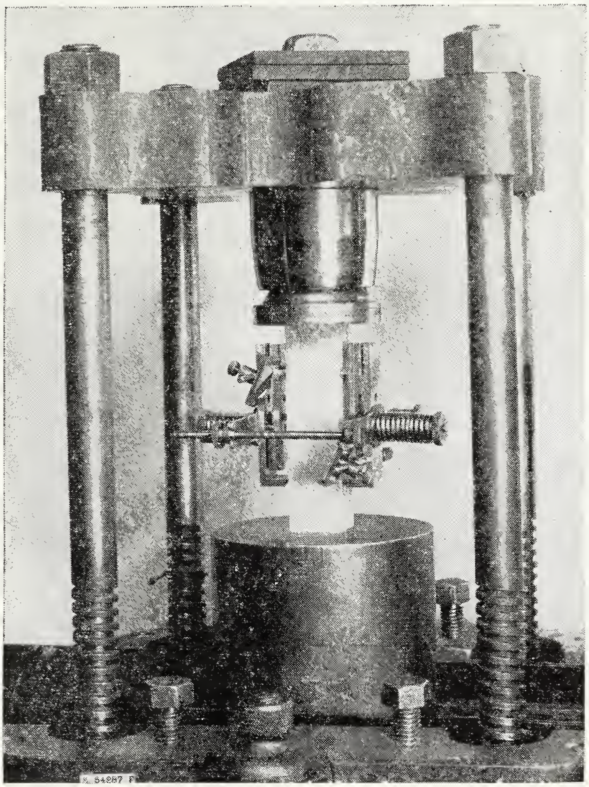


Fig. 3.—Compression Test of Plywood Prism Showing Roller Compressometer Attachment (2-in. Gage Length) Affording Average Deformation for Two Opposite Faces.

Method B, Alternate Test for Evaluation of Maximum Compressive Strength Only

9. In the alternate test for the evaluation of maximum compressive strength only, the load shall be applied through a spherical loading block with a continuous rate of crosshead movement of 0.003 in. per in. (cm per cm) of length per min. The maximum crushing strength shall be recorded and the maximum crushing stress calculated.

Moisture and Specific Gravity

10. The moisture content and specific gravity of each test specimen shall be determined as described in Sections 74 and 75.

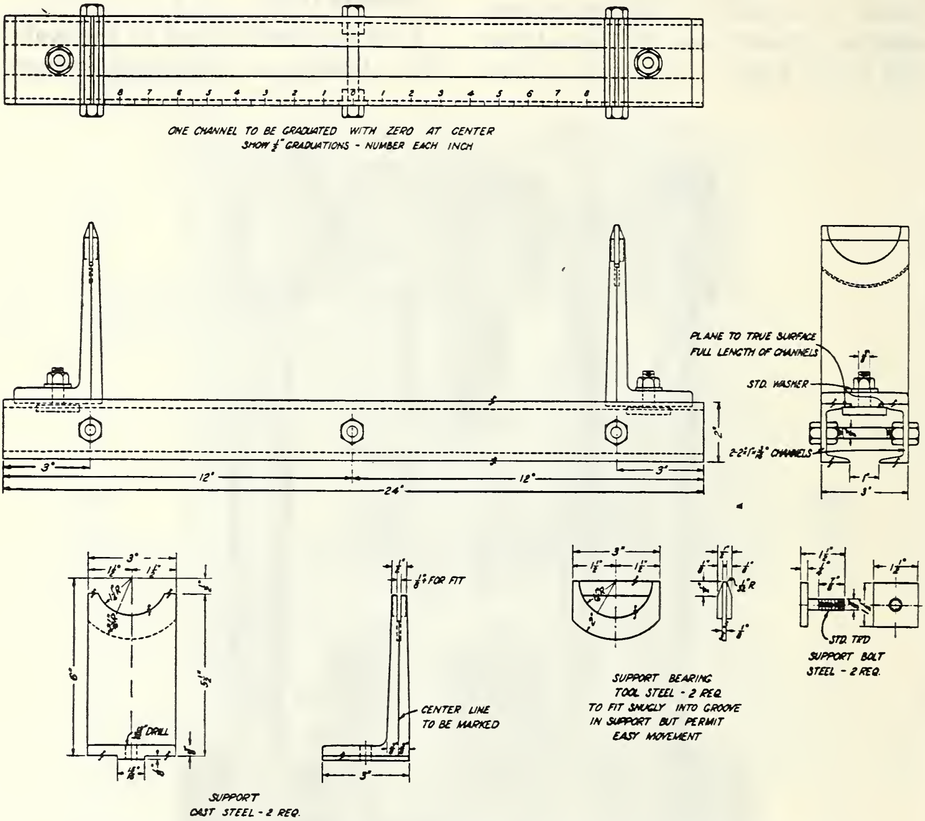


FIG. 4.—Apparatus for Static Bending Test Showing Details of Laterally Adjustable Supports.

STATIC BENDING

Direction of Grain or Fibers

11. The grain direction of the individual plies or laminations shall be parallel or perpendicular, or inclined at any other required angle to the length of the test specimen.

Test Specimen

12. The test specimen for plywood shall be rectangular in cross-section. The depth of the specimen shall be equal to the thickness of material, and the width shall be 1 in. (25 mm) for depths less than ¼ in. (6 mm) and 2 in. (5 cm) for greater depths (Note 1). When the grain direction of the face plies or laminations is parallel to the span, the length of the specimen (Note 2) shall be not less than 48 times the depth plus 2 in. (5 cm); when the grain direction of the face plies or laminations is perpendicular to the span, the specimen length shall be not less than 24 times the depth plus 2 in. (5 cm) (Note 3). The actual width and depth of each specimen shall be measured to an accuracy of not less than ±0.3 per cent.

Note 1.—In certain specific instances, it may be necessary or desirable to test specimens having a width greater than 1 or 2 in. (2.5 or 5 cm). When wider specimens are tested, the specimen width shall not exceed one-third of the span length and precaution shall be taken to insure uniform bearing across the entire width of the specimen at the load and reaction points.

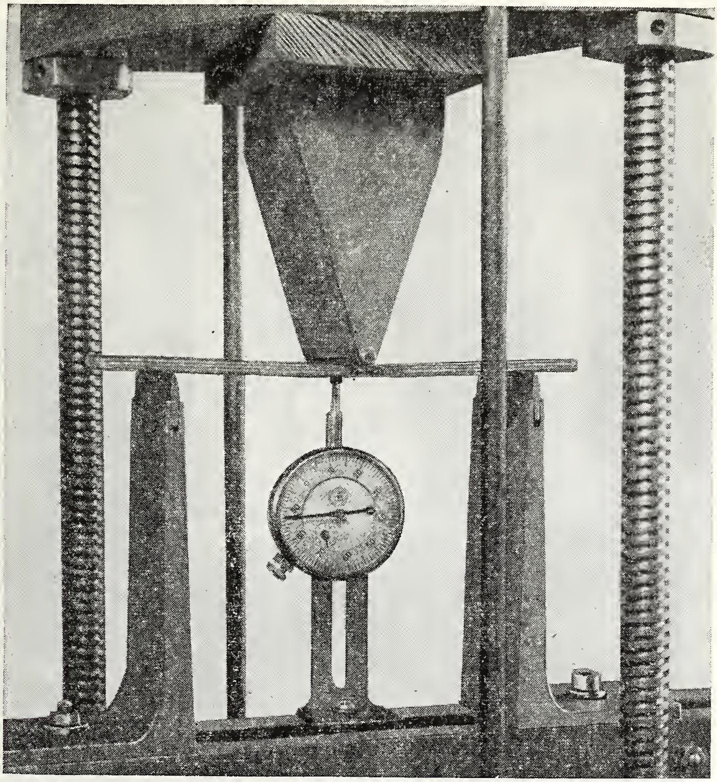


Fig. 5.—Static Bending Test of Plywood Showing Adjustable Supports and One Method of Attaching Dial Gage for Observing Deflections of Thin Material.

Note 2.—In cutting specimens to meet the length requirement of 2 in. (5 cm) plus the specified span length, it is not intended that the length be changed for small variations in thickness. Rather, it is intended that the nominal thickness of the material under test should be used for determining the specimen length.

Note 3.—When laminated wood products of complicated design are to be tested, the specifications above cannot be used indiscriminately. For certain conditions, different span-depth ratios may be required. When the grain direction of all laminations is similarly oriented, parallel or perpendicular to the span length, or if the test specimen is not made up of individual plies or laminae, and has its grain direction oriented in the same manner with respect to the span, the length of specimen may be taken as not less than 14 times the depth plus 2 in. (5 cm), and the span length as not less than 14 times the depth.

Span and Supports

13. Center loading shall be used. The span shall be not less than 48 times the nominal depth when the grain direction of the face plies or laminations of the test specimen is parallel to the span and not less than 24 times the nominal depth when the grain direction of the face plies or laminations is perpendicular to the span (see Note 1) or as indicated in

Note 3, Section 12. A 1-in. (2.5-cm) overhang shall be allowed at each end (Section 12). Round-nosed knife edges or roller-bearing supports may be used. In both instances, the supports shall be adjustable laterally to permit compensation for slight twist or warp in the specimen. The construction of this apparatus is shown in detail in Fig. 4 (Note 2). In cases where excessive local deformation may occur, suitable bearing plates shall be used.

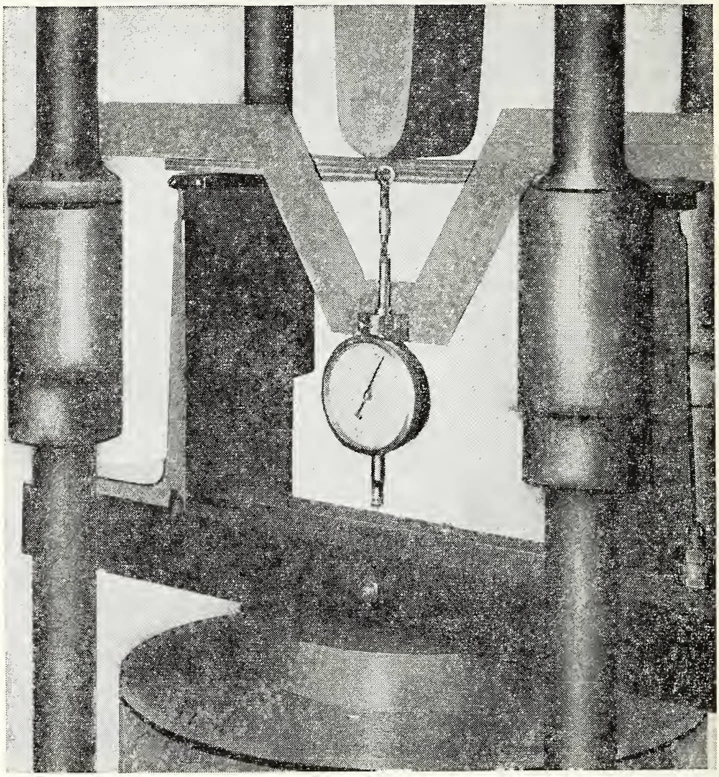


FIG. 6.—Static Bending Test on Thick Plywood Showing Roller Bearing at Supports and Special Yoke with Dial Gage for Measuring Deflection at the Neutral Axis.

NOTE 1.—Establishment of a span-depth ratio is required to allow an accurate comparison of test values for materials of different thicknesses. It should be noted that the span is based on the nominal thickness of the material and it is not intended that the spans be changed for small variations in thickness.

NOTE 2.—The method given herewith in detail illustrates an established satisfactory procedure for conducting static bending tests. It is recognized that other details of test may alternatively be satisfactorily used. It is a matter for individual laboratories to employ a method that is scientifically correct insofar as it follows the general principles established. Mention of the procedure used shall be made in the report of the tests.

Loading Block

14. A loading block having a radius of curvature of one and one-half times the depth of the test specimen for a chord length of not less than twice the depth of

the specimen shall be used. In cases where excessive local deformation may occur, suitable bearing plates shall be used.

Loading Procedure

15. The load shall be applied with a continuous motion of the movable head throughout the test. The rate of load application shall be such that the unit rate of fiber strain is equal to 0.0015 in. (0.04 mm) per in. of outer fiber length per min within a permissible variation of ±25 per cent. The rate of motion of the movable head may be calculated as follows:

$$N = \frac{zL^2}{6d}$$

where:

N = rate of motion of moving head, in in. (or cm) per min,

L = Span, in in. (or cm),

d = Depth of beam, in in. (or cm), and

z = Unit rate of fiber strain, in in. per in. (or cm per cm) of outer fiber length per min = 0.0015.

Load-Deflection Curves

16. Data for load-deflection curves may be taken to determine the modulus of elasticity, proportional limit, work to proportional limit, work to maximum load, and total work. Deflections may be taken by the methods indicated in Figs. 5 or 6, and readings shall be taken to the nearest 0.001 in. (0.02 mm). Increments of load shall be chosen so that not less than 12 and preferably 15 or more readings of load and deflection are taken to the proportional limit.

Moisture and Specific Gravity

17. The moisture content and specific gravity of each test specimen shall be determined as described in Sections 74 and 75.

TENSION

Scope

18. Experience has indicated the necessity of the following requirements for a satisfactory tension test specimen:

(*a*) The specimen should have a reduced cross-section at the center of the length to avoid failure in the grip areas.

(*b*) Transition from the full width of specimen at the ends to the reduced cross-section at the center should be gradual in order to minimize stress concentrations.

(*c*) When measurements of elastic properties are to be made, the zone of reduced cross-section at the center should be of sufficient length to accommodate an extensometer.

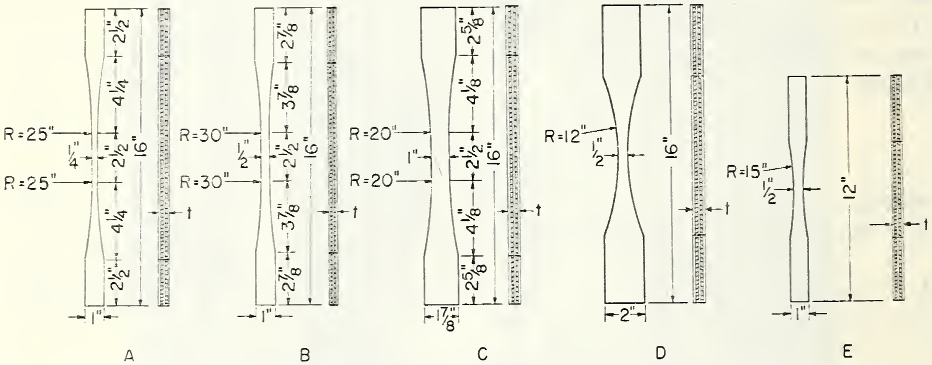
(*d*) The specimen should be small enough to permit adequate sampling of commercial sized sheets or panels but should be large enough to develop test loads which can be accurately determined with standard test equipment.

Test Specimen

19. (*a*) For the tension test, specimens of types A, B, C, D, or E, Fig. 7, are particularly recommended, but specimens of any other type that give equally satisfactory results may be used.

(*b*) When the evaluation of elastic properties as well as ultimate tensile strength is required, the size and shape of the test specimen shall be selected from the types A, B, or C (Fig. 7). The basis for selection shall be the grain angle and the thickness of the material. If the grain of the individual plies or laminations makes an angle other than 0 or 90 deg with the length of the specimen, type C shall be used regardless of the thickness of the material. For grain angles of individual lamina of 0 or 90 deg, type A shall be used for material over $\frac{1}{4}$ in. (6 mm) in thickness and type B for material $\frac{1}{4}$ in. (6 mm) or less in thickness. The specimen shall have a thickness equal to that of the material and the thickness and the width of each specimen at the critical section shall also be measured to an accuracy of not less than ±0.3 per cent.

(*c*) When the evaluation of the ultimate tensile strength only is required, specimens of types D and E may be used. Type D is designed for specimens greater than ¼ in. (6 mm) in thickness, and type E for specimens ¼ in. (6 mm) or less in thickness. Measurements of each specimen shall be made to an accuracy of not less than ±0.3 per cent.



Note.—A generous radius of curvature at the minimum section as provided in this specimen is highly desirable.

Fig. 7.—Dimensions and Details of Plywood Tension Test Specimens.

(*d*) The test specimens shall be properly shaped, using a template in conjunction with a vertical-spindle woodworking shaper or any other method that will give equally satisfactory results.

Loading Procedure

20. The load shall be applied continuously throughout the test at a rate of motion of the movable head of 0.035 in. (0.9 mm) per min. The specimen shall be held in wedge-type self-tightening and self-aligning grips.

Load-Deformation Curves

21. Data for load-deformation curves may be taken to determine the modulus of elasticity and the proportional limit. Increments of load shall be chosen so that not less than 12 and preferably 15 or more readings of load and deformation are taken to the proportional limit. The deformation apparatus shall be attached at the central portion of the length of the specimen at the center of the portion of constant cross-section. Deformation readings shall be taken to the nearest 0.0001 in. (0.002 mm). Figures 8 and 9 show 2-in. gage length Tripolitis extensometers that have been found satisfactory for this test.

Moisture and Specific Gravity

22. The moisture content and specific gravity of each test specimen shall be determined as described in Sections 74 and 75. For determining specific gravity, a separate specimen closely matched to the tension specimens shall be used.

PANEL SHEAR (FOREST PRODUCTS LABORATORY TEST)

Direction of Grain

23. The grain direction of the individual plies shall be at an angle of 0 or 90 deg with the edges of the panel.

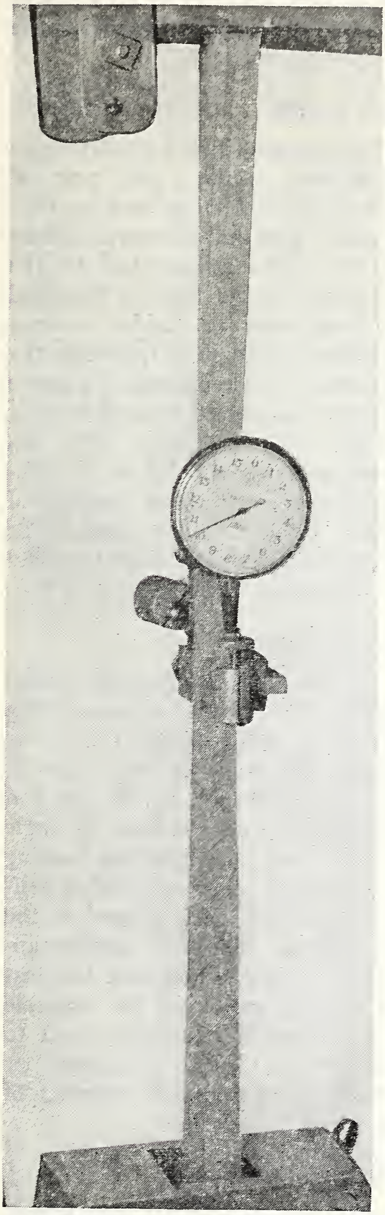


Fig. 8.—Tension Test of Thick Plywood Showing Nonaveraging Type of Extensometer (2-in. Gage Length).

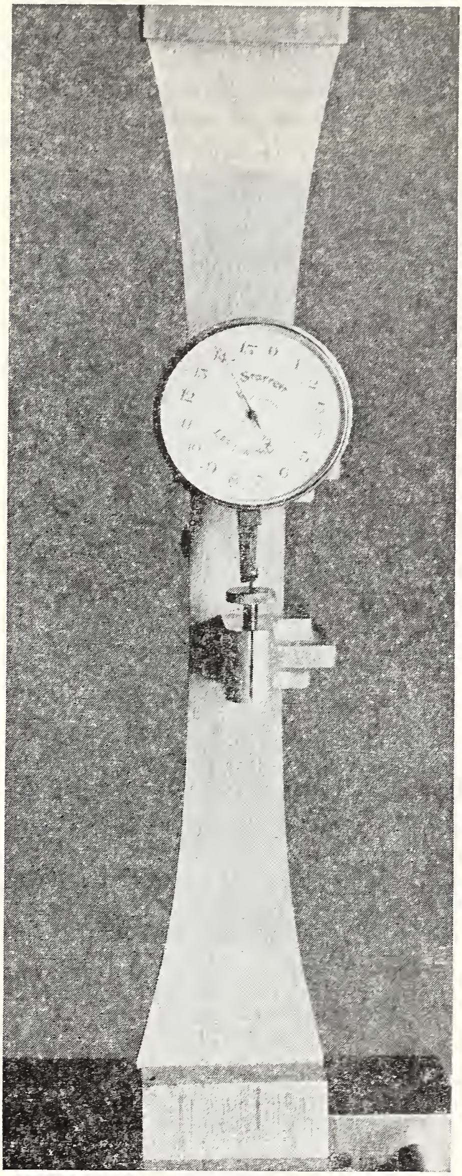


Fig. 9.—Tension Test of Plywood with Extensometer Attachment Showing Specimen Used When Load is Applied at an Angle Other Than 0 or 90 deg. to the Direction of the Grain of the Plies.

Test Specimen

24. The dimensions of the test specimen (Figs. 10 and 11) shall conform to the sizes prescribed in Table I for the respective thickness of plywood used. The size and thickness of reinforcing blocks (hard maple or birch) shall also conform to the values prescribed in this table. The thickness, length, and width of each specimen shall be measured to an accuracy of not less than ±0.3 per cent.

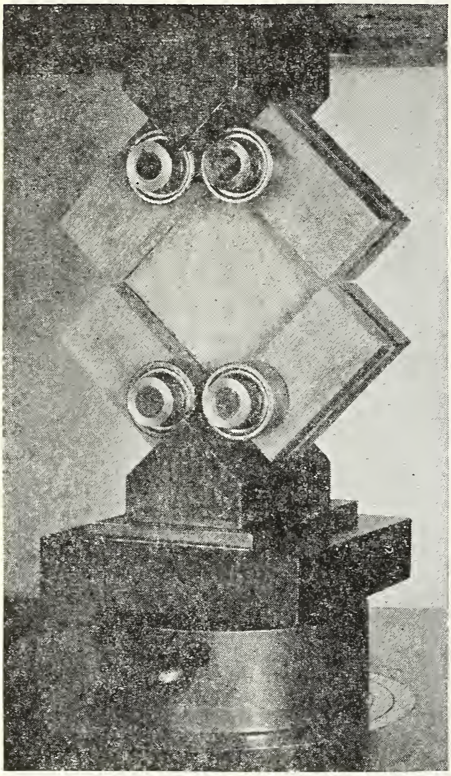


FIG. 10.—Panel Shear Test (F.P.L.) Showing Specimen Used and Method of Loading. Strain gages may be attached if necessary or desired.

Size and Location of Pins

25. The sizes and location of the pins used to load the panel shall be as prescribed in Table I. Care shall be taken in drilling the holes to make the surfaces smooth and the axes perpendicular to the plane of the plywood.

Pins and Rollers

26. The pins shall be of a quality equal to that of steel having a yield point of approximately 100,000 psi and an ultimate tensile strength of approximately 125,000 psi. The rollers shall be the ball or roller-bearing type of standard bearing sizes with an inside diameter approximately 0.001 in. larger than the pin diameter. Where necessary a sleeve bushing shall be pressed into the bearing to achieve this tolerance. For pin diameters in excess of 0.312 in., double-row ball bearings or roller bearings of equivalent strength shall be used. The outside bearing diameter shall be equal to that prescribed in Table I.

Loading Procedure

27. The load shall be applied by special steel loading blocks which articulate with the rollers and pins attached to the test specimen. The angle between faces of the loading block shall be 90 deg and between each face and the base the angle shall be 45 deg. A spherical bearing block, preferably of the suspended, self-aligning type shall be employed in the loading system. The load shall be applied continuously throughout the test with a uniform motion of the movable head of the testing machine equal to 0.005 in. per in. of length of diagonal per minute within a permissible variation of plus or minus 25 per cent.

Load-Deformation Curves

28. Data for load-deformation curves may be taken to determine the modulus of elasticity and the proportional limit. Strain gages shall be attached to the central portion of a diagonal on opposite sides of the specimen. The deformation shall be read to the nearest 0.0001 in.

TABLE I.—DIMENSIONS OF PLYWOOD PANEL SHEAR SPECIMENS.
(To be used with Fig. 11)

Plywood Thickness t, in.	Maximum Allowable Panel Size (between blocks), L, in.	Minimum Block Width, w, in.	Minimum Block Thickness, t', in.	Diameter of Pins, d, in.	Diameter of Pin Hole, in.	Diameter of Rollers, D, in.	Inner Edge of Block to Center Line of Pin Hole, a, in.	End of Block to Center Line of Pin Hole, b, in.
GROUP I WOODS (HIGH-DENSITY SPECIES)								
0.05 to 0.10	1.00	1.00	1/4	0.250	1/4	0.8661	1/4	3/8
0.10 to 0.20	2.00	1.00	3/8	0.390	25/64	1.1811	5/16	17/32
0.20 to 0.30	3.00	1.50	9/16	0.587	19/32	1.3780	15/32	17/32
0.30 to 0.40	4.00	2.00	3/4	0.784	51/64	1.8504	5/8	11/16
0.40 to 0.50	5.00	2.50	15/16	0.981	63/64	2.4409	25/32	15/16
0.50 to 0.60	6.00	3.00	1 1/8	1.178	1 3/16	2.8346	15/16	1 1/16
GROUP II WOODS (MEDIUM-DENSITY SPECIES)								
0.05 to 0.10	1.00	1.00	3/16	0.250	1/4	0.8661	1/4	3/8
0.10 to 0.20	2.00	1.00	5/16	0.390	25/64	1.1811	5/16	17/32
0.20 to 0.30	3.00	1.25	9/16	0.520	17/32	1.3780	15/32	17/32
0.30 to 0.40	4.00	1.75	11/16	0.784	51/64	1.8504	5/8	11/16
0.40 to 0.50	5.00	2.25	7/8	0.875	57/64	2.4409	25/32	15/16
0.50 to 0.60	6.00	2.50	1	1.178	1 3/16	2.8346	15/16	1 1/16
GROUP III WOODS (LOW-DENSITY SPECIES)								
0.05 to 0.10	1.00	0.75	3/16	0.250	1/4	0.8661	1/4	3/8
0.10 to 0.20	2.00	1.00	5/16	0.312	5/16	1.0236	5/16	13/32
0.20 to 0.30	3.00	1.25	7/16	0.438	7/16	1.2598	15/32	15/32
0.30 to 0.40	4.00	1.50	9/16	0.587	19/32	1.3780	5/8	1/2
0.40 to 0.50	5.00	2.00	11/16	0.784	51/64	1.8504	25/32	17/32
0.50 to 0.60	6.00	2.50	7/8	0.875	57/64	2.4409	15/16	25/32

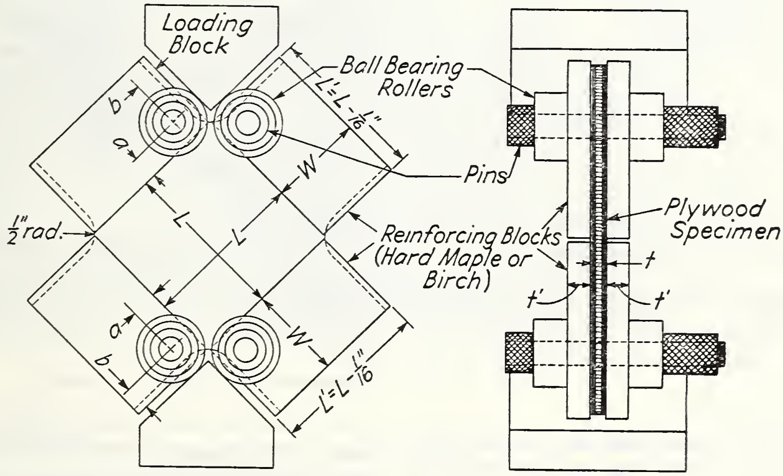


FIG. 11.—Plywood Panel Shear (F.P.L.) Frame Showing Size and Construction Details and Location of Pin and Rollers (To be used with Table I).

Calculation

29. The unit shear stress on the plywood panel shall be calculated as follows:

$$f_s = \frac{0.707\ P}{Lt}$$

where:

f_s = unit shear stress, in pounds per square inch,

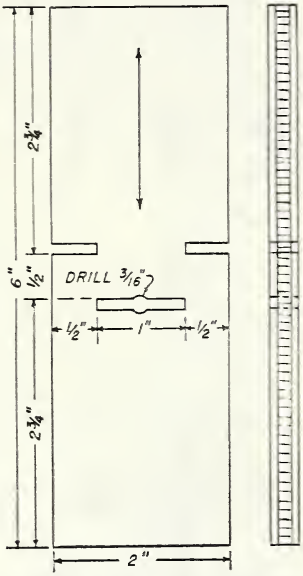
P = total applied load, in pounds,

L = side of square panel specimen (see Fig. 11), and

t = thickness of specimen (see Fig. 11), in inches.

Moisture and Specific Gravity

30. After the test a section shall be cut out of the panel, weighed and measured, and used to determine the moisture content and specific gravity of the specimen as described in Sections 74 and 75.



NOTE.—Arrow indicates direction of grain in face plies.

FIG. 12.—Tension Type Shear Specimen.

SHEARING STRENGTH (ALTERNATE METHOD USING TENSION-TYPE SHEAR SPECIMEN)

Direction of Grain

31. The grain direction of all plies shall be at 0 or 90 deg to the length of the specimen. The grain direction of the face plies shall be parallel to the length of the specimen.

Test Specimen

32. The test specimen shall be 6 in. (15 cm) in length, 2 in. (5 cm) in width, and of a thickness equal to the thickness of the material. The specimen shall be cut to provide a shearing length of ½ in. (12 mm) between saw slots, and the distance between shearing lines shall be 1 in. (25 mm) as shown in Fig. 12. The outer slots shall be cut, using a hollow ground grooving saw, and the inner slot shall be cut, after first drilling a pilot hole, using a jig saw or by any other method which will produce equally satisfactory results. The slots shall be carefully cut both as to length and position to provide the desired shear length. The thickness and shear length of each specimen shall be measured to an accuracy of not less than ±0.3 per cent.

Number of Specimens

33. A minimum of ten specimens shall be tested to determine the shearing strength of a given sample of material.

Loading Procedure

34. The load shall be applied continuously throughout the test at a rate of motion of the movable head of the testing machine of 0.025 in. (0.6 mm) per min until failure. The specimen shall be firmly held in wedge-type self-aligning and self-tightening grips. Maximum load only will be obtained.

Calculation

35. The shearing strength shall be calculated by dividing the maximum load by the product of the thickness of the specimen times twice the shear length.

Moisture and Specific Gravity

36. After the test a section shall be cut from the undamaged portion of the specimen, weighed and measured, and used to determine the moisture content and specific gravity of the specimen as described in Sections 74 and 75.

PLATE SHEAR (FOREST PRODUCTS LABORATORY TEST)

Direction of Grain

37. The grain direction of the individual plies or laminations shall be parallel

or perpendicular to the edges of the test specimen.

NOTE.—This method of test is primarily designed for material in which the grain of the individual plies or laminations is parallel or perpendicular to the edge of the specimen. It may be used, however, for specimens in which the grain is at 45 deg to the specimen edges if a four-ply panel with all plies of the same thickness is used. The controlling condition is that the EI (modulus of elasticity × moment of inertia) values along both diagonals shall be equal.

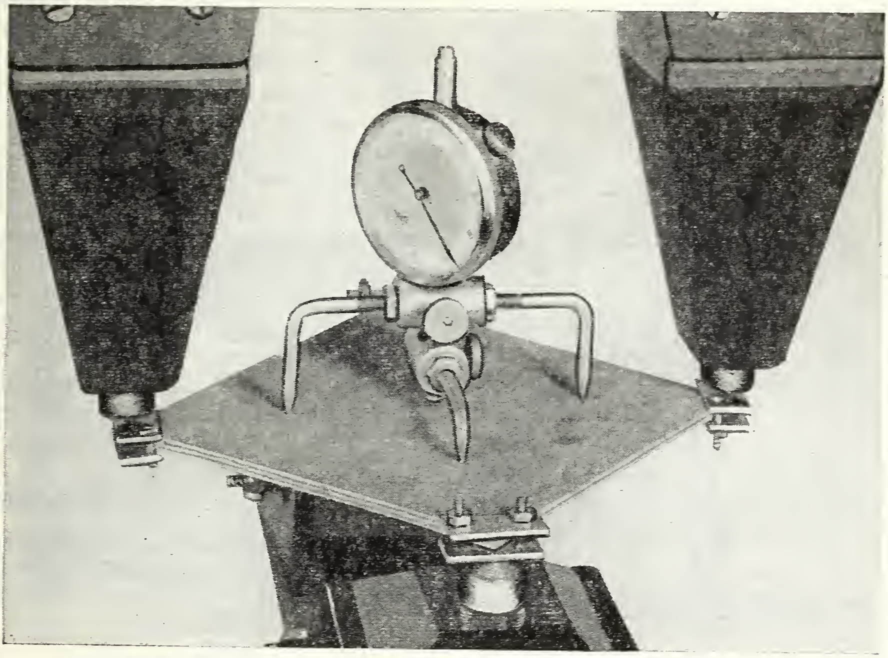


FIG. 13. Plate Shear Test (F.P.L.) of Plywood Showing Method of Loading and Observing the Differential Deformation Along the Two Diagonals.

Test Specimen

38. The test specimen shall be square, with the thickness equal to the thickness of the material and the length and width not less than 25 nor more than 40 times the thickness. The thickness, length, and width of each specimen shall be measured to an accuracy of not less than ±0.3 per cent. Care shall be taken to avoid obtaining test specimens with initial curvature.

Loading Procedure

39. The test specimen shall be supported on rounded supports having a radius of curvature not greater than $\frac{1}{4}$ in. (6 mm) on the opposite ends of a plate diagonal, and loaded in a similar manner on the opposite ends of the other diagonal. In order that the loads may be applied at the corners, metal plates shall first be attached as shown in Fig. 13. The loading and supporting frame shall be rigid. Figures 14 and 15 indicate the method of test and show details of the plate shear apparatus. The load shall be applied with a continuous and uniform motion of the movable head at a rate of 0.003 times the length of the plate in inches (cm), expressed in inches (cm) per minute, within a permissible variation of ± 25 per cent.

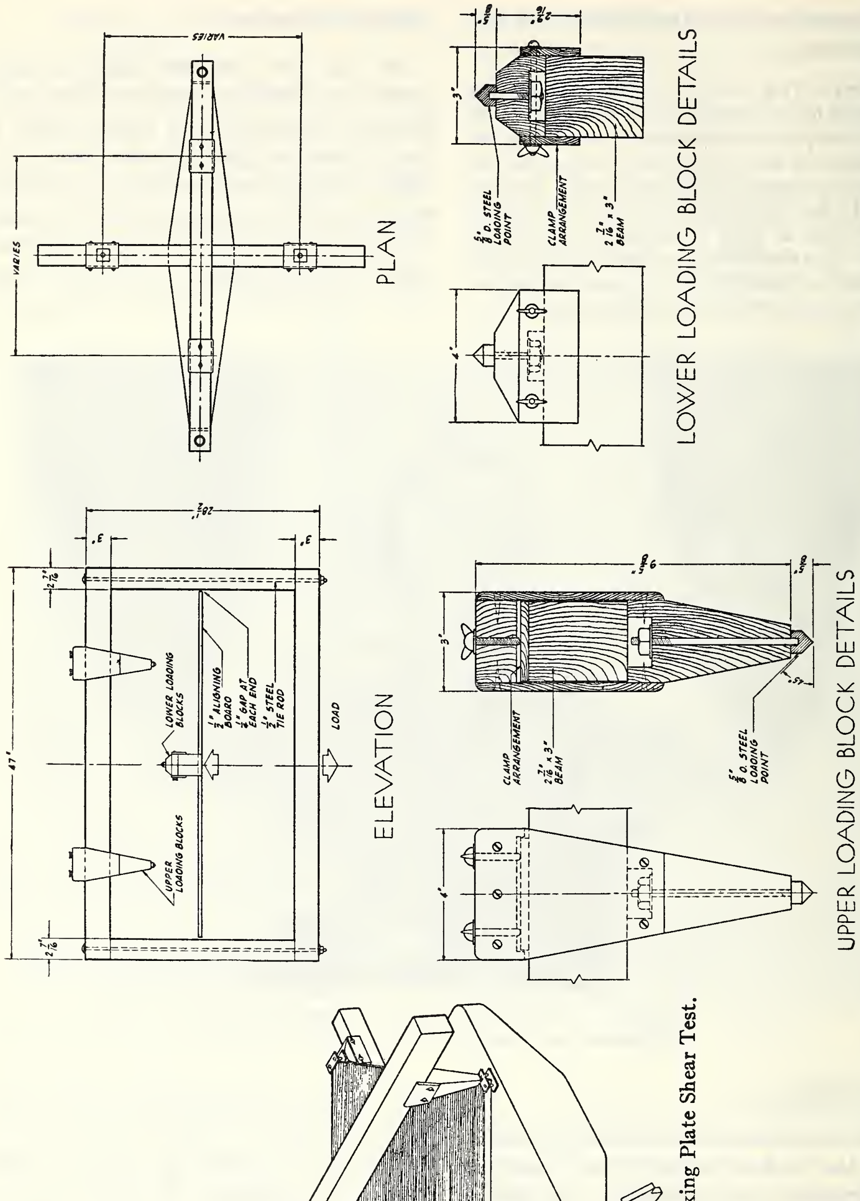


FIG. 15.—Apparatus for Plate Shear Test.

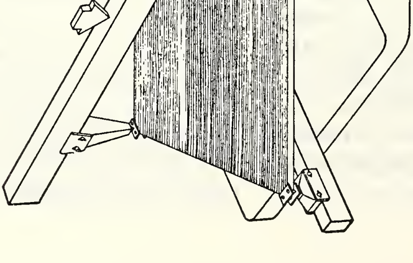


FIG. 14.—Method of Making Plate Shear Test.

Deformation Measurements

40. The deformation shall be measured to the nearest 0.001 in. (0.02 mm) at two points on each diagonal equidistant from the center of the plate. These measurements preferably shall be made at the quarter points of the diagonals, and if other points than these are chosen, care shall be taken to avoid locations near the plate corners to avoid the load and reaction effects. The plate shall not be stressed beyond its elastic range, and increments of load shall be chosen so that not less than 12 and preferably 15 load-deformation readings are taken. To eliminate the effects of slight initial curvature, two sets of data shall be obtained, the second set with the panel rotated 90 deg about an axis through the center of the plate and perpendicular to the plane of the plies. The two results shall be averaged to obtain the shear modulus for the plate. A satisfactory arrangement for measuring relative deformations is indicated in Fig. 13; the dial readings in this case give twice the average deflection of the four points.

Calculation

41. The shearing modulus of elasticity shall be calculated as follows:

$$G = \frac{3u^2 P}{2h^3 w}$$

where:

G = shearing modulus, in pounds per square inch (kg per sq cm),

P = load applied to each corner, in pounds (kg),

h = thickness of the plate, in inches (cm),

w = deflection relative to the center, in inches (cm), and

u = distance from the center of the panel to the point where the deflection is measured, in inches (cm).

NOTE.—The average values of P and w are generally taken from the slope of a previously plotted load-deflection curve.

Moisture and Specific Gravity

42. The moisture content and specific gravity of each test specimen shall be determined as described in Sections 74 and 75. Where additional tests are to be made on the plate a satisfactory moisture specimen may be provided when the specimen is cut out, in which case this moisture specimen shall be subjected to the same conditioning as the plate proper.

TOUGHNESS

Test Specimen

43. The toughness test specimen to be used in conjunction with the Forest Products Laboratory toughness testing machine shall be $\frac{5}{8}$ in. (16 mm) in width for material less than $\frac{5}{8}$ in. (16 mm) in thickness, and the thickness of the specimen shall be equal to that of the material. For material more than $\frac{5}{8}$ in. (16 mm) in thickness, the width shall be equal to the thickness of the material, thus making the specimen square in cross-section. The length shall be determined from the thickness of the material in accordance with Table II. The actual cross-sectional dimensions, and the specimen and span length shall be measured to an accuracy of not less than ±0.3 per cent.

TABLE II.—LENGTH OF TOUGHNESS TEST SPECIMENS.

Plywood Thickness, in. (mm)	Span Length, in. (cm)	Specimen Length, in. (cm)
Up to $\frac{1}{8}$ (3), incl.	2 (5)	4 (10)
Over $\frac{1}{8}$ (3) to $\frac{1}{4}$ (6), incl.	3 (7.5)	5 (12.5)
Over $\frac{1}{4}$ (6) to $\frac{3}{8}$ (9), incl.	5 (12.5)	7 (17.5)
Over $\frac{3}{8}$ (9) to $\frac{1}{2}$ (12), incl.	6 (15)	8 (20)
Over $\frac{1}{2}$ (12) to $\frac{5}{8}$ (16), incl.	8 (20)	10 (25)
Over $\frac{5}{8}$ (16) to $\frac{3}{4}$ (18), incl.	9 (23)	11 (27.5)
Over $\frac{3}{4}$ (18) to 1 (25), incl.	12 (30)	14 (35)

Apparatus

44. The toughness testing machine (Note) shall consist of a frame supporting a pendulum, being so arranged that a measured amount of the energy from the fall of the pendulum may be applied to a test specimen. The pendulum shall consist of a bar to which is fastened a weight adjustable to different positions and shall carry at its upper end a drum or pulley whose center provides the axis of rotation. The force shall be applied to the specimen by means of a flexible steel cable passing over the drum. A stationary graduated scale or dial and a vernier operated by the moving drum shall be provided for reading the angles through which the pendulum swings. The machine shall be adjusted before test so that the pendulum hangs truly vertical and adjusted to correct for friction. The cable shall be adjusted so that the load is applied to the specimen when the pendulum swings to within approximately 15 deg of the vertical so as to produce complete failure by the time the downward swing is completed.

NOTE.—The set-up shown in Fig. 16 has been found to give satisfactory results.

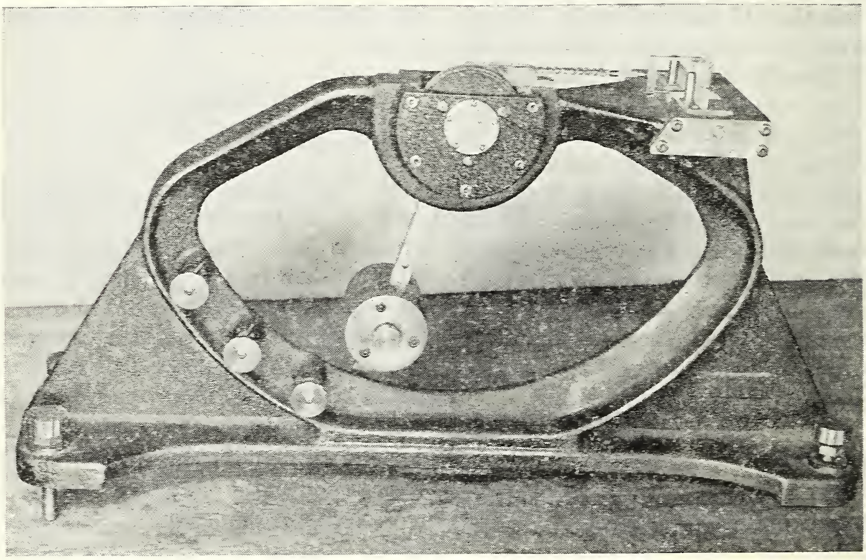


FIG. 16.—Toughness Test of Plywood Showing Load Applied to Specimen When Pendulum is Approximately 15 deg. from the Vertical.

Span and Supports

45. The test specimen shall be supported as a beam on two vertical pins, which exert reactions that are perpendicular to the plane of the plies or laminations. These pins shall be adjusted to the span length taken from Table II which provides for a specimen overhang of 1 in. (2.5 cm) at each end.

Loading Procedure

46. The load shall be applied at the center of the span perpendicular to the plane of the plies. The load shall be applied through a tup, attached to a flexible cable, having a radius of curvature approximately equal to one and one-half times the depth of the test specimen. The weight position and initial angle of the pendulum shall be chosen so that

complete failure of the specimen is obtained on one drop. Most satisfactory results are obtained when the difference between the initial and final angle is at least 10 deg.

NOTE.—In order properly to satisfy these conditions, it will be necessary to use a toughness testing machine of proper capacity for the specimens being tested. The larger size specimens can be tested in the large size Forest Products Laboratory toughness machine which has a maximum capacity of 673 in-lb., while tests of smaller specimens can be made in the 20 in-lb. capacity intermediate size machine.

Calculation

47. The initial and final angle shall be read to the nearest 0.2 deg by means of the attached vernier. The toughness shall then be calculated as follows:

$$T = wL(\cos A_2 - \cos A_1)$$

where:

T = toughness (work per specimen), in inch pounds (centimeter kilograms),

w = weight of the pendulum, in pounds (kilograms),

L = distance from the center of the supporting axis to the center of gravity of the pendulum, in inches (centimeters),

A_1 = initial angle (Note), in degrees, and

A_2 = final angle the pendulum makes with the vertical after failure of the test specimen, in degrees.

NOTE.—Since friction is compensated for in the machine adjustment, the initial angle may be regarded as exactly 30, 45, or 60 deg, as the case may be.

Moisture and Specific Gravity

48. The moisture content and specific gravity of each test specimen shall be determined as described in Sections 74 and 75.

ROCKWELL HARDNESS

(For material with specific gravity equal to or greater than 1.0)

Test Specimen

49. The test specimen shall be at least 1 in. (2.5 cm) square, with a minimum thickness of 0.25 in. (6 mm) unless it has been verified that for the thickness used the hardness values are not affected by the supporting surface and that no imprint shows on the under surface of the specimen after testing. The surfaces of the specimen shall be smooth and normal to the axis of the penetrator and the specimen shall rest solidly on the anvil.

Apparatus

50. The standard Rockwell hardness tester described in the Standard Methods of Test for Rockwell Hardness and Rockwell Superficial Hardness of Metallic Materials (A.S.T.M. designation: E 18),[3] shall be used and the M scale employed, unless otherwise specified. The Rockwell M scale hardness test requires the use of a $\frac{1}{4}$-in. hardened steel ball penetrator, a minor load of 10 kg and a major load of 100 kg, with readings taken on the red dial.

Procedure

51. (*a*) Without the test specimen in place the Rockwell tester shall be adjusted by means of the dash pot so that the time of application of the major load is from 4 to 5 sec with the 100-kg load. With the specimen in place, the minor load of 10 kg shall be applied and the zero setting (130 on the red scale) made 10 sec thereafter. The major load shall then be applied by tripping the crank handle. The major load shall be removed within 7 to 8 sec thereafter and the hardness reading shall be made 45 sec thereafter unless the pointer comes to rest in a shorter time.

(*b*) The Rockwell M hardness number may be more than 100 or may be negative. Determine the number of times the needle passes the zero on the red scale on application of the major load and subtract the number of times the needle passes zero on removal of the major load. If the result is zero the reading is over 100; if 1, 0 to 100; if 2, the reading is negative. The Rockwell hardness number and scale letter shall be given in reporting the hardness of the material.

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[3] 1958 Book of ASTM Standards, Part 3.

Moisture Content and Specific Gravity

52. The moisture content and specific gravity of each test specimen shall be determined as described in Sections 74 and 75.

SWELLING AND RECOVERY OF COMPRESSED WOOD PRODUCTS DUE TO MOISTURE ABSORPTION

Direction of Grain or Fibers

53. The grain direction of the face plies or laminations shall be perpendicular to the length of the test specimen.

Test Specimen

54. Six test specimens shall be used in each determination of swelling or recovery. Each specimen shall be 2.00 ±0.10 in. (50 ± 2.5 mm) in length (perpendicular to the grain direction of the face plies); 0.0625 ± 0.005 in. (1.6 ± 0.1 mm) in width (parallel to the grain direction of the face plies); and of a thickness equal to the thickness of the material.

Preparation of Test Specimen

55. Care shall be taken in preparing the specimens to obtain cut surfaces that are not overheated, charred, or burnished. All cut surfaces shall be finished with No. 000 emery paper. All original surfaces of the specimen shall be removed with No. 000 emery paper prior to test.

Procedure

56. The dimension in the direction of compression of all specimens shall be measured at the center of the specimens to the nearest 0.001 in. (0.02 mm) prior to immersion or drying. Three of these specimens (control specimens) shall be dried for 24 hr at a temperature of 103 ± 2 C, cooled in a desiccator over calcium chloride, and remeasured. The remaining three specimens (immersion specimens) shall be immersed for 24 hr in water at 25 ± 2 C. They shall then be removed, the surface moisture absorbed by a dry cloth, measured, and dried for 24 hr. at 103 ± 2 C. After drying they shall be cooled in a desiccator over calcium chloride, and remeasured.

Calculation

57. The percentages of recovery, and swelling plus recovery shall be calculated as follows:

$$R = \left(\frac{d_1 d_5}{d_2 d_3} - 1\right) \times 100$$

$$S = \left(\frac{d_1 d_4}{d_2 d_3} - 1\right) \times 100$$

where:

R = percentage recovery = percentage change in dimension (caused by recovery of compression) from the original oven-dry condition to the oven-dry condition after soaking,

S = percentage swelling plus recovery = percentage change in dimension from the oven-dry to water-soaked condition, and includes change due to the moisture absorption of the material and recovery of compression,

d_1 = sum of dimensions of three control specimens parallel to direction of compression, air-dry,

d_2 = sum of dimensions of three control specimens parallel to direction of compression, oven-dry,

d_3 = sum of dimensions of three immersion specimens parallel to direction of compression, air-dry.

d_4 = sum of dimensions of three immersion specimens parallel to direction of compression, water-soaked, and
d_5 = sum of dimensions of three immersion specimens parallel to direction of compression, oven-dry.

Moisture Absorption of Compressed Wood Products

Direction of Grain or Fibers

58. The grain direction of the face plies or laminations shall be perpendicular to the length of the specimen.

Test Specimen

59. The test specimen shall be 1 in. (2.5 cm) in width parallel to the grain direction of the face plies, 3 in. (7.5 cm) in length perpendicular to the grain direction of the face plies, and for material less than $\frac{3}{8}$ in. (9 mm) in thickness the specimen thickness shall be equal to that of the material. When the material thickness is greater than $\frac{3}{8}$ in. (9 mm), the specimen shall be $\frac{3}{8}$ in. (9 mm) in thickness and shall be secured from the center of the sample.

Preparation of Specimen

60. Care shall be taken in preparing the test specimens to obtain cut surfaces that are not overheated, charred, or burnished. All cut surfaces shall be finished with No. 000 emery paper. All original surfaces on the specimen shall be removed with No. 000 emery paper prior to test.

Procedure

61. The test specimens shall be dried for 24 hr. at 50 ± 2 C. After drying, the specimens shall be cooled in a desiccator over calcium chloride, weighed, and completely immersed for 24 hr. in water maintained at a temperature of 25 ± 2 C. The specimens shall then be removed, one at a time, the surface moisture quickly absorbed by a dry cloth, and reweighed. The weights of each specimen shall be determined to an accuracy of not less than ±0.2 per cent.

Calculation

62. The percentage of moisture absorption shall be calculated as follows:

$$A = \frac{W_F - W_I}{W_I} \times 100$$

where:

A = absorption, in per cent,
W_F = final weight after immersion, and
W_I = initial weight after drying.

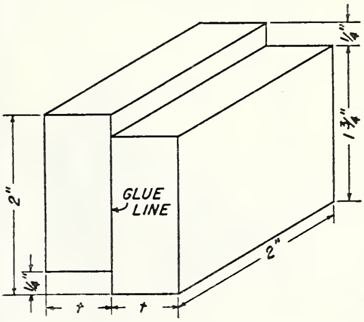

Fig. 17.—Glue Block Shear Specimen.

Glue Block Shear Test

Direction of Grain or Fibers

63. The grain direction of the individual laminations shall be parallel to the direction of loading.

Test Specimen

64. The test specimen shall be 2 in. (5 cm) in width and 2 in. (5 cm) in height. The specimen shall consist of two laminations of equal thickness, and the thickness, t, of each lamination shall be $\frac{3}{4}$ in. (18 mm). Each lamination shall be $1\frac{3}{4}$ in. (4.4 cm) in height, with an overlap between the two laminations of $1\frac{1}{2}$ in. (3.7 cm). Details of the specimen design are shown in Fig. 17.

Preparation of Specimen

65. Care shall be taken in preparing the test specimens to make the loaded surfaces smooth and parallel to each other and perpendicular to the height. Care shall also be exercised in reducing the lengths of the laminations to $1\frac{3}{4}$ in. (4.4 cm) to insure that the saw cuts extend to, but not beyond, the glue line. The width and height of the specimen at the glue line shall be measured to an accuracy of not less than ± 0.3 per cent to determine the shear area.

Loading Procedure

66. The load shall be applied through a self-aligning seat to insure uniform lateral distribution of the load. The load shall be applied with a continuous motion of the movable head to maximum load at a rate of 0.015 in. (0.4 mm) per min within a permissible variation of plus or minus 25 per cent. The method of loading shown in Fig. 18 has been found satisfactory.

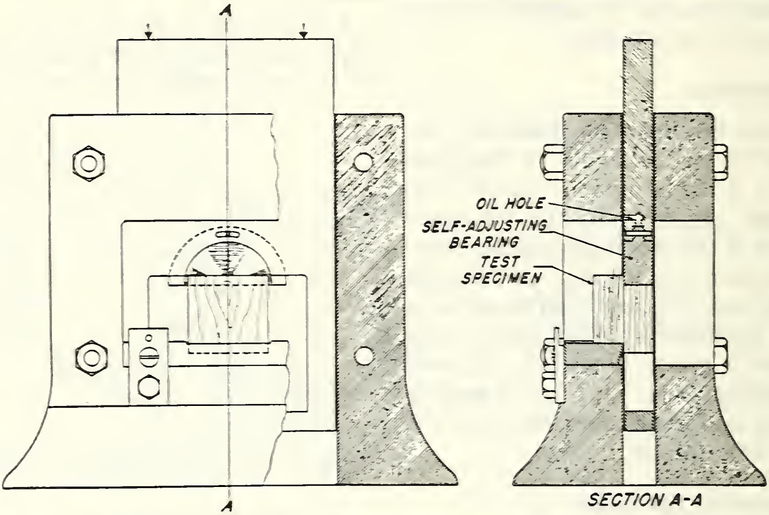

Fig. 18.—Shearing Tool Showing Method of Loading for Glue Block Shear Test.

Report

67. The shear stress at failure, based on the overlap area between the two laminations, and the percentage of wood failure shall be reported for each specimen.

Plywood Glue Shear Test

Direction of Grain or Fibers

68. The direction of grain in each face ply shall be parallel to the length of the specimen and the grain direction of the core shall be perpendicular to the length of the specimen.

Test Specimen

69. The test specimen shall be nominally 1 in. (2.5 cm) in width, $3\frac{1}{4}$ in. (8.2 cm) in length, and of a thickness equal to that of the three-ply plywood selected. When the plywood consists of more than three plies, it shall be stripped of all except any three selected plies prior to test. The length of shear area shall be 1 in. (2.5 cm) when the face ply thickness

is greater than $\frac{1}{20}$ in. (1 mm), and shall be $\frac{1}{2}$ in. (12 mm) when the face plies are $\frac{1}{20}$ in. (1 mm) or less in thickness as shown in Fig. 19, specimens *A* and *B*, respectively.

Preparation of Specimen

70. The test specimens shall be cut to proper size before the notches are cut. The notches shall be cut to proper width, depth, and location, using a hollow ground grooving saw or any other method that will give equally satisfactory results. The width of the specimen and the distance between notches shall be measured to an accuracy of not less than ±0.3 per cent to determine the shear area.

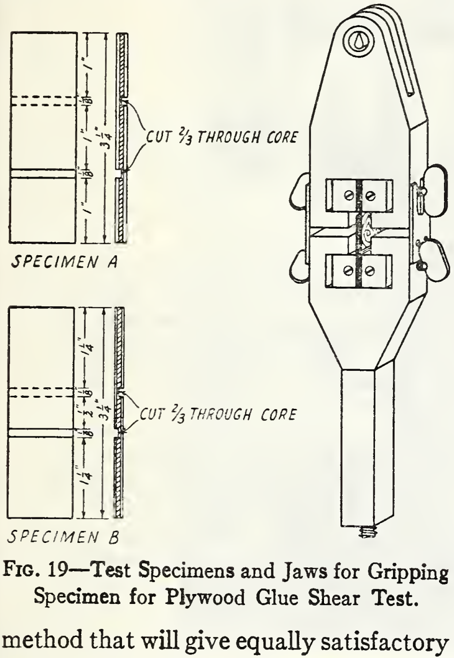

FIG. 19—Test Specimens and Jaws for Gripping Specimen for Plywood Glue Shear Test.

Condition of Specimen

71. The specimens may be tested dry, in which case they shall have a moisture content of from 8 to 12 per cent at the time of test, or they may be tested after a soaking or boil test, depending on the type of information desired.

Loading Procedure

72. The ends of the specimen shall be firmly gripped during test and the load shall be applied at a rate of 600 to 1000 lb per min (270 to 450 kg) until failure. The jaws for gripping the specimen, and the complete apparatus, shown in Figs. 19 and 20, have been found satisfactory.

Report

73. The load at failure and the percentage of wood failure shall be reported for each specimen. All strengths shall be expressed in pounds per square inch (kg per sq cm) of shear area. To obtain comparable strengths for the two types of specimen, the unit shear stress in pounds per square inch (kg per sq cm) obtained for specimens of $\frac{1}{2}$ sq in. (3.3 sq cm) shear area shall be reduced by 10 per cent.

MOISTURE CONTENT AND SPECIFIC GRAVITY

Procedure

74. The test specimen shall be accurately weighed and measured at the time of test (Note 1). After the test a sample which is to be used to determine the moisture content, shall be cut from the body of the specimen (Note 2) near the point of failure. This moisture sample shall be weighed immediately and dried in an oven at 103 ± 2 C until approximately constant weight is attained. After drying, the sample shall be weighed immediately. The weights of the test specimens and of the moisture samples shall be determined to an accuracy of not less than ±0.2 per cent.

NOTE 1.—Veneer, plywood, and laminated materials may splinter somewhat in certain tests, so that the original specimen may not be intact at the end of a test. In such instances, the specimens should obviously be weighed before test.

NOTE 2.—For specimens of thin material or of small size, it may be desirable to use the entire specimen as a moisture sample. In specimens where the original weight cannot be obtained (for example, the panel shear specimen) the sample must be treated as a new specimen and shall be measured as well as weighed prior to drying.

Calculations

75. (*a*) *Moisture Content.*—The moisture content (Note 1) shall be calculated as follows:

$$M = \frac{W - F}{F} \times 100$$

where:

M = moisture content, in per cent,
W = initial weight, and
F = final weight.

(*b*) *Specific Gravity.*—The specific gravity (Notes 1 and 2) shall be calculated as follows:

$$\text{Specific gravity} = \frac{KF}{Lwt}$$

where:

F = Final weight when oven-dry, in grams,
L = Length of coupon, in inches (or centimeters),
w = Width of coupon, in inches (or centimeters),
t = Thickness of coupon, in inches (or centimeters),
K = 1, when metric units of weight and measurement are used, and
K = 0.061, when metric units of weight and English units of measurement are used.

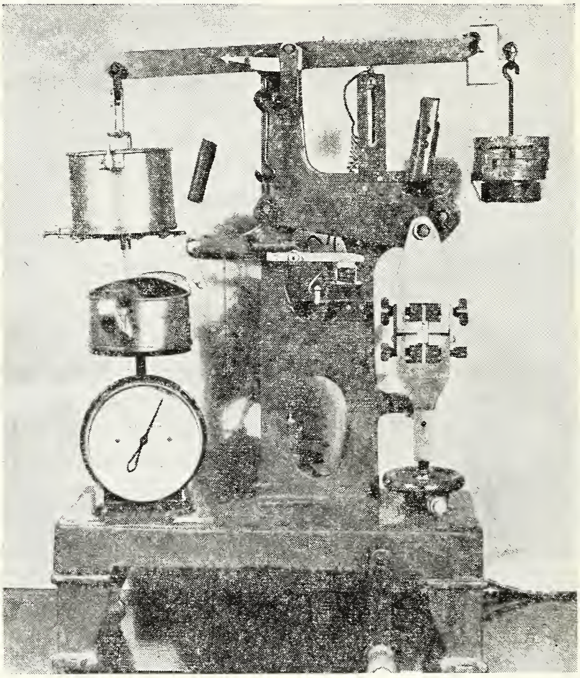

FIG. 20.—Apparatus for Plywood Glue Shear Test.

NOTE 1.—The moisture content and specific gravity as determined above are the average values for the entire specimen. In plywood made up of thin veneers, the glue may constitute a significant part of the total weight and as a result the calculated specific gravities and moisture contents may vary substantially from the true values for the veneers. In some instances it may be desirable to take this into account.

NOTE 2.—The specific gravity so obtained is based on the volume at test and weight when oven-dry. If desired, the specific gravity may be obtained on an oven-dry weight and volume basis, using the procedure described in the Standard Methods of Testing Small Clear Specimens of Timber (ASTM Designation: D 143).[4] In each instance, the basis of the specific gravity value with respect to volume and moisture condition shall be stated.

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[4] See p. 1.

APPROVED AS
AMERICAN STANDARD
BY THE AMERICAN STANDARDS ASSOCIATIO
ASA NO.: O8.1-1958
UDC 691.14:620.17

Tentative Methods of Test for
EVALUATING THE PROPERTIES OF BUILDING FIBERBOARDS[1]

ASTM Designation: D 1037 - 56 T

Issued, 1949; Revised, 1952, 1955, 1956.[2]

These Tentative Methods have been approved by the sponsoring committee and accepted by the Society in accordance with established procedures, for use pending adoption as standard. Suggestions for revisions should be addressed to the Society at 1916 Race St., Philadelphia 3, Pa.

The methods of test presented herein are intended to provide a means for accurate and complete evaluation of the physical and mechanical properties of fiberboard products from the standpoint of their use as engineering materials. The data obtained may be used for comparison purposes with other engineering materials of construction, or, where applicable, to engineering design. The methods may also be used in connection with specification requirements, but are not as a whole intended for use in quality control in manufacture, where for certain properties such as static bending, a more rapid and less complete or less accurate method may suffice.

Of the methods of test presented, some have been in generally accepted use for many years, some are modifications and refinements of previously developed methods, and some are more recent developments. All of the methods have been extensively used in current evaluations of building boards.

Scope

1. These methods cover procedures for determining the properties of building fiberboards as follows:

	Sections
Size and Appearance of Boards	6 to 9
Strength Properties:	
Static Bending	10 to 19
Tensile Strength Parallel to Surface	20 to 26
Tensile Strength Perpendicular to Surface	27 to 32
Nail Holding:	
Lateral Nail Resistance Test	33 to 38
Nail Withdrawal Test	39 to 45
Nail-Head Pull-Through Test	46 to 52
Hardness	53 to 58
Shear Strength in Plane of the Board	59 to 64
Glue Line Shear Test (Block Type)	65 to 68
Moisture Tests:	
Water Absorption	69 to 75
Linear Variation with Change in Moisture Content	76 to 79
Accelerated Aging	80 to 84
Cupping and Twisting	85
Moisture Content and Specific Gravity	86 to 87

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[1] Under the standardization procedure of the Society, these methods are under the jurisdiction of the ASTM Committee D-7 on Wood.

[2] Latest revision accepted by the Society at the Annual Meeting, June, 1956.

Selection of Test

2. Not all the tests outlined in these methods may be necessary to evaluate any particular board for any specified use. In each instance, therefore, it will be necessary to determine which tests shall be made.

Test Specimens

3. The number of specimens to be chosen for test and the method of their selection depend on the purpose of the particular tests under consideration, so that no general rule can be given to cover all instances. It is recommended that whenever possible, a sufficient number of tests be made to permit statistical treatment of the test data. In the evaluation of a fiberboard material, specimens for test should be obtained from a representative number of boards. In properties reflecting differences due to the machine direction of the board, specimens from each board shall be selected both with the long dimension parallel to the long dimension of the sheet, and with the long dimension perpendicular to the long dimension of the sheet.

Control of Moisture Content and Temperature

4. The physical and mechanical properties of building boards depend on the moisture content at time of test. Therefore, material for test in the dry condition shall be conditioned to constant weight and moisure content in a conditioning chamber maintained at a relative humidity of 65 ± 1 per cent and a temperature of 20 ± 3 C (68 ± 6 F) (Notes 1 and 2). If there is any departure from this recommended condition, it shall be so stated in the report.

NOTE 1.—In following the recommendation that the temperature be controlled to 20 ± 3 C (68 ± 6 F), it should be understood that it is desirable to maintain the temperature as nearly constant as possible at some temperature within this range.

NOTE 2.—Requirements for relative humidity vary for different materials. The condition given above meets the standard for wood and wood-base materials.

Report

5. The data recorded shall include, in addition to the actual test results and data called for specifically under each test, a description of the material, sampling procedure, record of any conditioning or treatment, and notes regarding any special details that may have a bearing on the test results.

SIZE AND APPEARANCE OF BOARDS

Size of Finished Board

6. When measurements of finished boards are required, the width of each finished board shall be obtained by measuring the width at each end and at midlength to an accuracy of not less than ±0.3 per cent or $\frac{1}{16}$ in. (2 mm) whichever is smaller. Likewise, three measurements of length shall be made, one near each edge, and one at midwidth with like accuracy.

Variation in Thickness

7. For the determination of variations in thickness, specimens at least 6 in. (15 cm) square shall be used. The thickness of each specimen shall be measured at five points, near each corner and near the center, and the average thickness and the variation in thickness noted. These measurements shall be made to an accuracy of not less than ±0.3 per cent, when possible.

Specific Gravity

8. Specific gravity (or density) and moisture content determinations are required on each static bending test specimen. The moisture content shall be determined from a coupon taken from each bending specimen, and the specific gravity computed from the dimensions and weight of the bending specimen at time of test and the moisture content.

The average specific gravity of the bending specimens as determined after conditioning to equilibrium (Section 4) shall be reported as the specific gravity of the board. The maximum and minimum values for specific gravity (based on volume at test and weight when oven dry) shall also be noted.

NOTE.—When it is desired to make specific gravity determinations independent of any other test, specimens of any convenient size may be selected. These shall be measured, weighed, and dried as outlined in Sections 86 and 87.

Surface Finish

9. The finish of both surfaces shall be described. A photograph of each surface may be taken to show the texture of the board. This photograph shall show suitable numbering so that the building board may be properly identified.

STATIC BENDING

Scope

10. Static bending tests shall be made both on specimens when conditioned and when soaked. One half of the test specimens shall be prepared with the long dimension parallel and the other half with the long dimension perpendicular to the long dimension of the board in order to evaluate directional properties.

Test Specimen

11. Each test specimen shall be 3 in. (7.5 cm) in width if the nominal thickness is greater than $\frac{1}{4}$ in. (6 mm), and 2 in. (5 cm) in width if the nominal thickness is $\frac{1}{4}$ in. (6 mm) or less. The depth (thickness) shall be the thickness of the material. The length of each specimen shall be 2 in. (5 cm) plus 24 times the nominal depth (Notes 1 and 2). The width, length, and thickness of each specimen shall be measured to an accuracy of not less than ±0.3 per cent.

NOTE 1.—In cutting specimens to meet the length requirement of 2 in. (5 cm) plus 24 times the nominal thickness, it is not intended that the length be changed for small variations in thickness. Rather it is the thought that the nominal thickness of the board under test should be used for determining the specimen length.

NOTE 2.—Long-span specimens are desired for tests in bending so that the effects of deflections due to shear deformations will be minimized and the values of moduli of elasticity obtained from the bending tests will approximate the true moduli of the materials.

Specimens Soaked Before Test

12. The specimens to be tested in the soaked condition shall be submerged in water at 20 ± 3 C (68 ± 6 F) for 24 hr before test and shall be tested immediately upon removal from the water. When it is desired to obtain the effect of complete saturation the specimens shall be soaked for such longer period as may be necessary. The time of soaking and the amount of water absorbed shall be reported.

Span and Supports

13. The span for each test shall be 24 times the nominal thickness (depth) of the specimen (Note 1). The supports shall be such that no appreciable crushing of the specimen will occur at these points during the test. The supports either shall be rounded or shall be knife edges provided with rollers and plates under the specimen at these points. When rounded supports, such as those shown in Fig. 1, are used, the radius of the rounded portion shall be at least $1\frac{1}{2}$ times the thickness of the material being tested. If the material under test deviates from a plane (Note 2), laterally adjustable supports[3] shall be provided.

NOTE 1.—Establishment of a span-depth ratio is required to allow an accurate comparison of test values for materials of different thicknesses. It should be noted that the span is based on the nominal thickness of the material and it is not intended that the spans be changed for small variations in thickness.

NOTE 2.—The laterally adjustable knife

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[3] Details of laterally adjustable supports may be found in Fig. 4 of the Standard Methods of Testing Veneer, Plywood, and Other Glued Veneer Constructions (ASTM Designation: D 805), p. 57.

edges may be necessary for the specimens tested in the soaked condition because of warping or twisting that may occur due to soaking.

Center Loading

14. The specimens shall be loaded at the center of span with the load applied to the finished face at a uniform rate through a loading block rounded as is shown in Fig. 1. The bearing blocks shall be at least 3 in. (7.5 cm) in width and shall have a thickness (parallel to span) equal to twice the radius of curvature of the rounded portion of the loading block. The radius of the rounded portion shall be approximately equal to $1\frac{1}{2}$ times the thickness of the specimen.

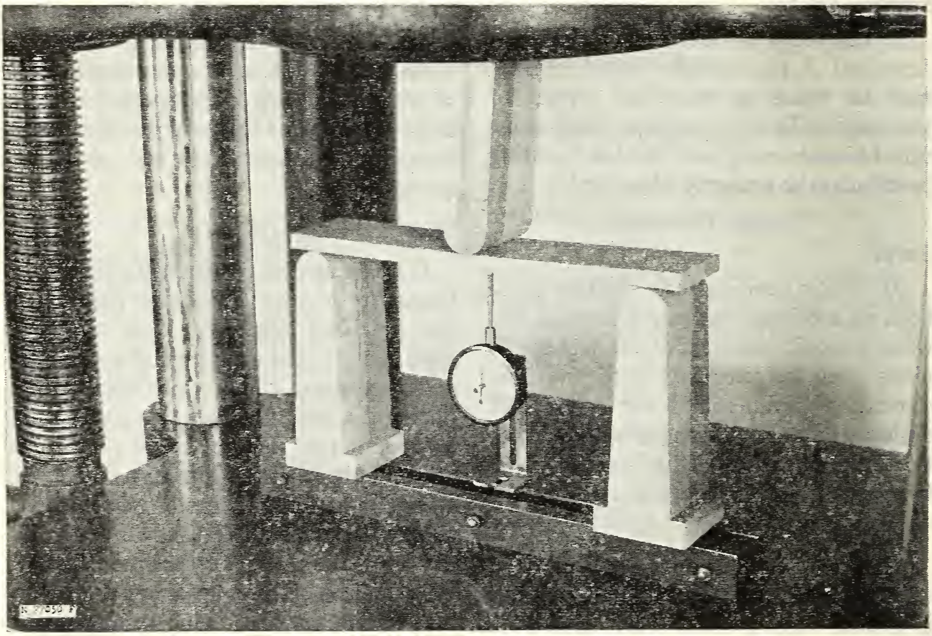

FIG. 1.—Static Bending Test Assembly.

Speed of Testing

15. The load shall be applied continuously throughout test at a uniform rate of motion of the movable cross head of the testing machine as calculated by the following formula (Notes 1 and 2):

$$N = \frac{zL^2}{6d}$$

where:

N = rate of motion of moving head, in in. (or cm) per min,

z = unit rate of fiber strain, in in. per in. (or cm per cm) of outer fiber length per minute (0.005),

L = span, in in. (or cm), and

d = depth (thickness) of specimen, in in. (or cm).

NOTE 1.—The testing-machine speed used shall not vary by more than ±50 per cent from that specified for a given test. The testing-machine speed used shall be recorded on the data sheet. The crosshead speed shall mean the free-running, or no-load, crosshead speed for testing machines of the mechanical-drive type, and the loaded crosshead speed for testing machines of the hydraulic-loading type.

NOTE 2.—The calculated rates of head descent are, therefore, 0.12 in. (3 mm) per min for specimens ¼ in. (6 mm) in thickness, 0.24 in. (6 mm) per min for specimens ½ in. (12 mm) in thickness, 0.36 in. (9 mm) per min for specimens ¾ in. (18 mm) in thickness, and 0.48 in. (12 mm) per min for specimens 1 in. (25 mm) in thickness.

Load-Deflection Curves

16. Load-deflection curves shall be obtained to maximum load for all bending tests. The deflection of the center of the specimen shall be obtaining by measuring the deflection of the bottom of the specimen at the center by means of an indicating dial (Note) attached to the base of the testing jig, with the dial plunger in contact with the bottom of the specimen at the center. This arrangement is shown in Fig. 1. The load and deflection at first failure and at maximum load shall be noted. Readings of deflection shall be taken at least to the nearest 0.005 in. (0.1 mm). Figure 2 shows a typical load-deflection curve.

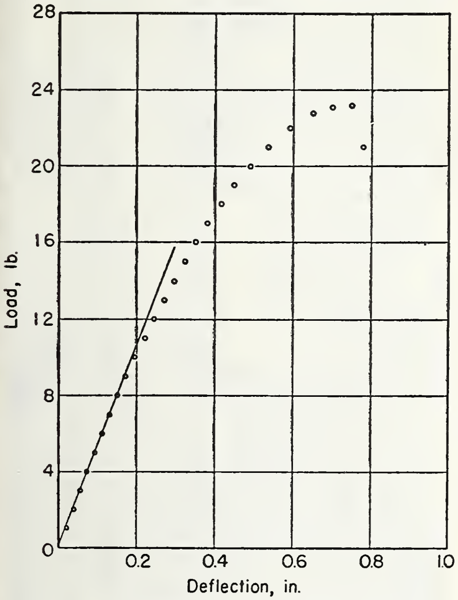

FIG. 2.—Typical Load-Deflection Curve for Static Bending Test.

NOTE.—The range of standard 0.001-in. indicating dials is 1 in. The total deflection of some thicknesses of building boards may exceed 1 in. at failure. When this happens, either a 2-in. total-travel indicating dial or a suitable 2:1 reducing lever in conjunction with a 1-in. travel dial should be used so that maximum deflections can be obtained.

Description of Failure

17. The character of the failure shall be noted. The report shall include the sequence of failure and note whether or not the initial failure was in compression or tension. Photographs of typical failures will be helpful.

Moisture Content and Specific Gravity

18. The specimen shall be weighed immediately before test, and after test a moisture section 1 in. (25 mm) by the width of specimen shall be cut from the body of the specimen. The moisture content and specific gravity of each specimen shall be determined in accordance with Sections 8, 86, and 87.

Calculations and Report

19. (*a*) The modulus of rupture shall be calculated for each specimen by the following formula, and the values determined shall be included in the report:

$$R = \frac{3PL}{2bd^2}$$

(*b*) The stress at proportional limit shall be calculated for each specimen by the following formula, and the values determined shall be included in the report:

$$Spl = \frac{3P_1L}{2bd^2}$$

(*c*) The stiffness (apparent modulus of elasticity) shall be calculated for each specimen by the following formula, and the values determined shall be included in the report:

$$E = \frac{P_1L^3}{4bd^3y_1}$$

(*d*) The work to maximum load shall be calculated for each specimen by the following formula, and the values determined shall be included in the report:

$$Wml = \frac{A}{bdL}$$

where:

A = area under load-deflection curve to maximum load, in.-lb (cm-kg),
b = width of specimen, in. (or cm),
d = thickness (depth) of specimen, in. (or cm),
E = stiffness (apparent modulus of elasticity), psi (or kg per sq cm),
L = length of span, in. (or cm),
P = maximum load, lb (or kg),
P_1 = load at proportional limit, lb (or kg),
R = modulus of rupture, psi (or kg per sq cm),
Spl = stress at proportional limit, psi (or kg per sq cm),
Wml = work to maximum load, in.-lb per cu in. (or kg per cu cm),
y_1 = center deflection at proportional limit load, in. (or cm).

TENSILE STRENGTH PARALLEL TO SURFACE

Scope

20. The test for tensile strength parallel to the surface shall be made on specimens both in the dry and in the soaked condition. Tests shall be made of specimens both with the long dimension parallel and perpendicular to the long dimension of the board to determine whether or not the material has directional properties.

NOTE.—This test may be applied to material 1 in. (25 mm) or less in thickness. When the material exceeds 1 in. (25 mm) in thickness, crushing at the grips during test is likely to affect adversely the test values obtained. It is recommended that for material greater than 1 in. (25 mm) in thickness, the material be resawed to ½ in. (12 mm) thickness. Test values obtained from resawed specimens may be only approximate, because strengths of material near the surface may vary from the remainder.

Test Specimen

21. Each test specimen shall be prepared as shown in Fig. 3. The reduced section shall be cut to the size shown with a band saw. The thickness and the minimum width of each specimen at the reduced section shall be measured to an accuracy of not less than ±0.3 per cent. The minimum width of the reduced section shall be determined to at least the nearest 0.01 in. (0.25 mm). These two dimensions shall be used to determine the net cross-sectional area for determining maximum stress.

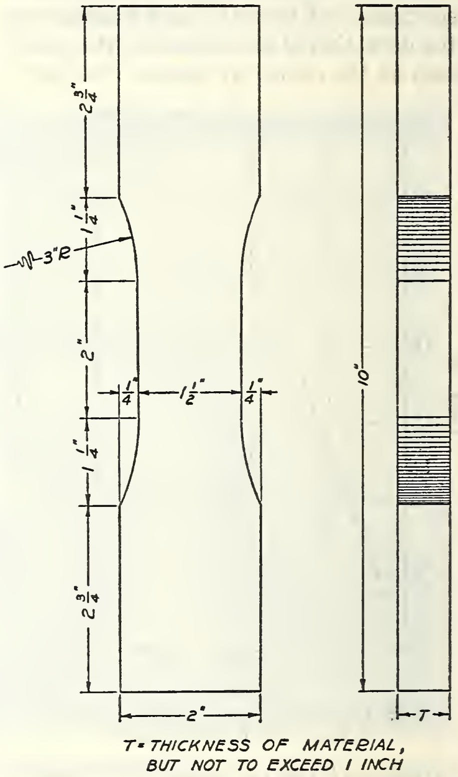

FIG. 3.—Detail of Specimen for Tension Test Parallel to Surface.

Specimens Soaked Before Test

22. Specimens to be tested in the

soaked condition shall be prepared in accordance with Section 12.

Method of Loading

23. Self-aligning, self-tightening grips with serrated gripping surfaces at least 2 in. (5 cm) in width and at least 2 in. (5 cm) in length shall be used to transmit the load from the testing machine to the specimen. Figure 4 shows a typical assembly for the tension test of building boards.

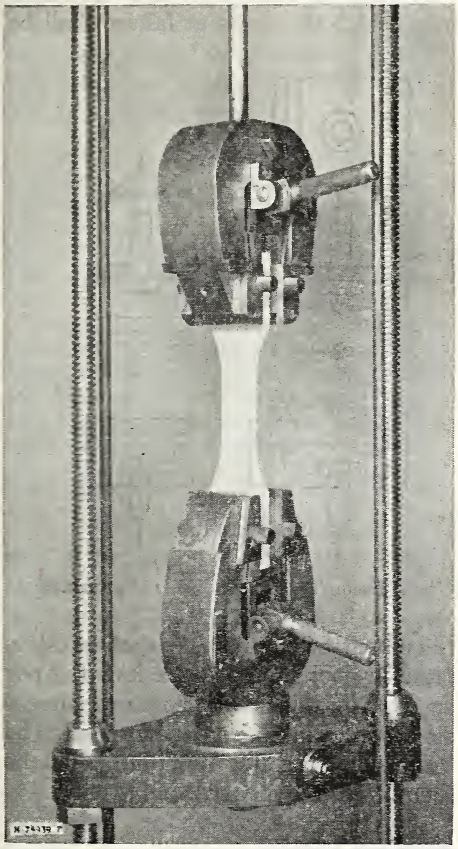

FIG. 4.—Assembly for Tension Test Parallel to Surface.

Speed of Testing

24. The load shall be applied continuously throughout the test at a uniform rate of motion of the movable crosshead of the testing machine of 0.15 in. (4 mm) per min (see Note 1, Section 15).

Test Data and Report

25. Maximum loads shall be obtained from which the stress shall be calculated. If the failure is within $\frac{1}{2}$ in. (12 mm) of either grip, the test value shall be disregarded. The report shall include maximum loads and the location and description of the failures.

Moisture Content

26. The moisture content of each specimen shall be determined as specified in Sections 8, 86, and 87.

TENSILE STRENGTH PERPENDICULAR TO SURFACE

Scope

27. The test for tensile strength perpendicular to the surface shall be made on specimens in the dry condition to determined cohesion of the fiberboard in the direction perpendicular to the plane of the board.

NOTE.—This test is included because of the increased use of fiberboards where wood, plywood, or other materials are glued to the fiberboard. Tests in the soaked condition shall be made if the material is to be used under severe weather conditions.

Test Specimen

28. The test specimen shall be 2 in. (5 cm) square and the thickness shall be that of the finished board. Loading blocks of steel or aluminum alloy 2 in. (5 cm) square and 1 in. (2.5 cm) in thickness shall be effectively bonded with a suitable adhesive (Note) to the 2-in. (5-cm) square faces of the specimen as shown in Fig. 5, which is a detail of the specimen and loading fixtures. Cross-sectional dimensions of the specimen shall be measured to an accuracy of not less than ±0.3 per cent.

Note.—Any suitable adhesive that provides an adequate bond may be used for bonding the fiberboard specimen to the loading blocks. Epoxy resins are recommended as a satisfactory bonding agent. The pressure required to bond the blocks to the specimen will depend on the density of the board and the adhesive used, and should not be so great as to measurably damage the fiberboard. The resulting bond shall be at least as strong as the cohesive strength of the material perpendicular to the plane of the fiberboard.

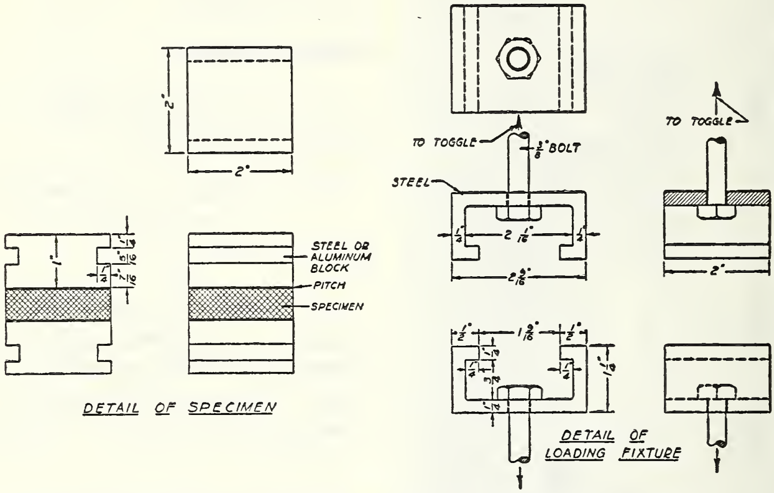

Fig. 5.—Detail of Specimen and Loading Fixture for Tension Test Perpendicular to Surface.

Method of Test

29. Loading fixtures, such as are shown in Fig. 5, attached to the heads of the testing machine shall engage the blocks attached to the specimen. The specimen shall be stressed by separation of the heads of the testing machine until failure occurs. The direction of loading shall be as nearly perpendicular to the faces of the fiberboard as possible, and the center of load shall pass through the center of the specimen.

Speed of Testing

30. The load shall be applied continuously throughout the test at a uniform rate of motion of the movable crosshead of the testing machine of 0.08 in. per in. (0.08 cm per cm) of thickness per minute.

Note.—It is not intended that the testing machine speed shall be varied for small differences in fiberboard thickness, but rather that it shall not vary more than ±50 per cent from that specified above (see Note 1, Section 15).

Test Data and Report

31. Maximum loads shall be obtained from which the stress at failure shall be calculated. Strength values shall be calculated in pounds per square inch (kg per sq cm), for which the measured dimensions of the specimen shall be used. The location of the line of failure shall be included in the report.

Moisture Content

32. The moisture content of each specimen shall be determined on a separate sample prepared from the same material, as specified in Sections 86(*b*) and 87.

LATERAL NAIL RESISTANCE TEST

Scope

33. Nail-holding tests shall be made to measure the resistance of a nail to

lateral movement through a fiberboard. One half of the specimens shall be selected and positioned in test so that the movement of the nail will be parallel, and one half so that the movement of the nail will be perpendicular to the long dimension of the board for evaluation of directional properties. When general information is desired the sixpenny common nail or its equivalent should be used. For special applications, however, this procedure is adaptable to other sizes and types of fasteners.

NOTE 1.—If this test is performed on some hardboards, the nail may bend and pull out of the stirrup. If this happens, the maximum load will be an apparent and not the true resistance of the board, and will only indicate that the resistance is some figure higher than the apparent value. When this happens it shall be noted.

NOTE 2.—Values obtained from this test are dependent on the thickness of the specimen. Values, however, are not directly proportional to the thickness. For this reason values obtained from tests of different boards can only be compared exactly if the thicknesses are equal.

Test Specimen

34. Each specimen shall be 3 in. (7.5 cm) in width and of convenient length, and shall have a nail 0.113 in. (2.80 mm) in diameter (or as near thereto as possible) driven at right angles to the face of the board so that about an equal length of nail projects from each face. The nail shall be centered on the width and located $\frac{1}{4}$, $\frac{1}{2}$, or $\frac{3}{4}$ in. (6, 12, or 18 mm) from one end. Tests shall be made for all three-end clearances for each material tested. The thickness of each specimen shall be measured to an accuracy of not less than ±0.3 per cent.

NOTE.—A sixpenny common wire nail meets this requirement. In certain instances it may be more desirable to use a pointed steel pin of known hardness than the nail. The type of nail or pin used shall be described in the report.

Specimens Soaked Before Test

35. Specimens to be tested in the soaked condition shall be prepared in accordance with Section 12, and the nails shall be driven before the specimens are soaked.

Method of Loading

36. The end of the specimen opposite to the end with the nail shall be clamped in a position parallel to the movement of the testing machine. Grips such as are suitable for tension tests parallel to the plane of the fiberboard are suitable. The nail is engaged by the stirrup, which is in turn connected to one platen of the testing machine by a rod. A typical test assembly for measuring the resistance of a nail in the lateral direction is shown in Fig. 6. The stirrup and connections are detailed in Fig. 7. For other types of

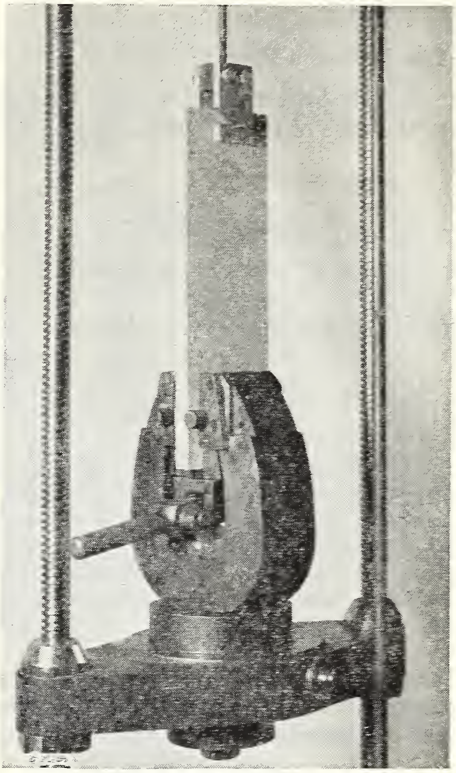

FIG. 6.—Test Assembly for Measuring the Resistance of Nails to Lateral Movement.

fasteners, such as staples, modification of the stirrup may be necessary.

Speed of Testing

37. The specimen shall be loaded continuously throughout the test by separation of the heads of the testing machine at a uniform rate of crosshead speed of 0.25 in. (6 mm) per min (see Note 1, Section 15).

Test Data and Report

38. The load required to move the nail to the edge of the specimen shall be the measure of the lateral resistance. The maximum load and the nature of failure shall be included in the report.

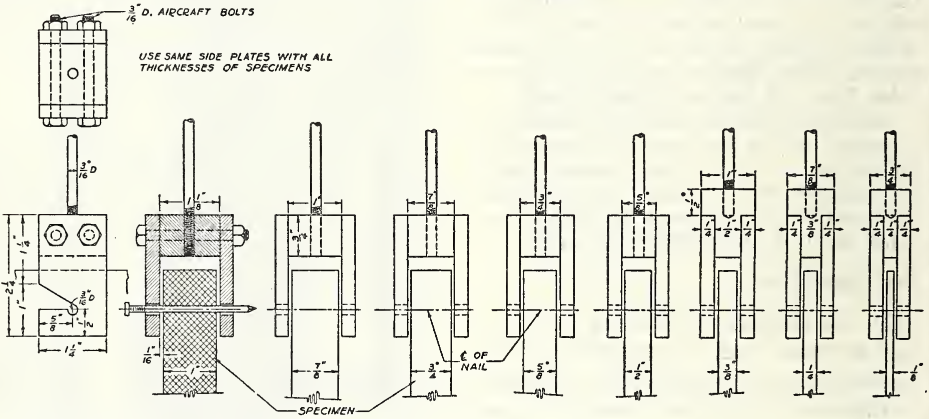

FIG. 7.—Detail of Stirrups and Connections for Measuring the Resistance of Nails to Lateral Movement.

NAIL WITHDRAWAL TEST

Scope

39. Nail-holding tests shall be made on nails driven through the fiberboard from face to face to measure the resistance to withdrawal in a plane normal to the face. When general information is desired the sixpenny common nail or its equivalent should be used. For special applications, however, this procedure is adaptable to other sizes and types of fasteners.

Test Specimen

40. The test specimen shall be of convenient size (at least 3 in. (7.5 cm) in width and 6 in. (15 cm) in length). Nails 0.113 in. (2.80 mm) in diameter shall be driven through the board at right angles to the face, and at least ½ in. (12 mm) of the shank portion shall project above the surface of the material. The thickness of each specimen shall be measured to an accuracy of not less than ±0.3 per cent.

NOTE 1.—A sixpenny common wire nail meets this requirement. In certain instances it may be more desirable to use a pointed steel pin of known hardness than a nail. A head or other suitable end shall then be provided to engage the load-applying fixture and the nail or pin used shall be described in the report.

NOTE 2.—Where the use of a particular nail or fastener requires less than ½ in. of shank projecting above the surface, then only sufficient length shall be left to permit engagement in the testing assembly.

Specimens Tested in the Dry Condition

41. When the tests are made in the dry state, the withdrawals shall be made immediately after the nails have been driven.

Specimens Soaked Before Test

42. Specimens to be tested in the soaked condition shall be prepared in accordance with Section 12, and the nails

shall be driven before the specimens are soaked.

Method of Loading

43. The assembly for the direct-withdrawal test is shown in Fig. 8. The specimen-holding fixture shall be attached to the lower platen of the testing machine. The specimen shall be inserted in the fixture with the heads of the nails up, as shown. The heads of the nails shall be engaged by the load-applying fixture equipped with a slot for easy attachment. This loading fixture shall be attached to the upper platen of the testing machine. Loads shall be applied by separation of the platens of the testing machine. The fitting is detailed in Fig. 9. For other types of fasteners, such as staples, modification of the loading fixture may be necessary.

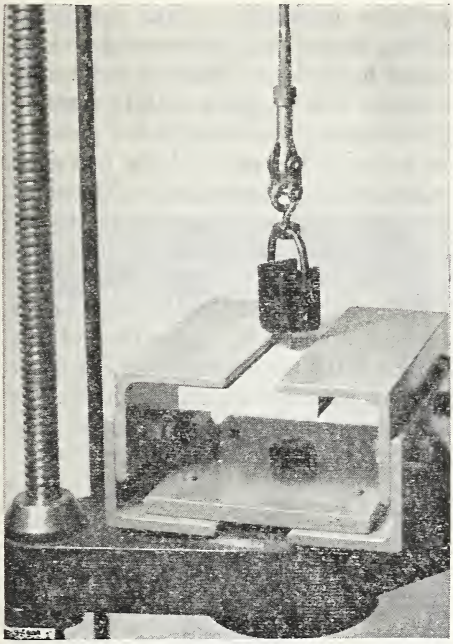

Fig. 8.—Test Assembly for Measuring the Resistance of Nails to Direct Withdrawal.

Speed of Testing

44. Load shall be applied to the specimen throughout the test by a uniform motion of the movable head of the testing machine at a rate of 0.06 in. (1.5 mm) per min (see Note 1, Section 15).

Test Data and Report

45. The maximum load required to withdraw the nail shall be the measure of resistance of the material to direct nail withdrawal, and shall be included in the report.

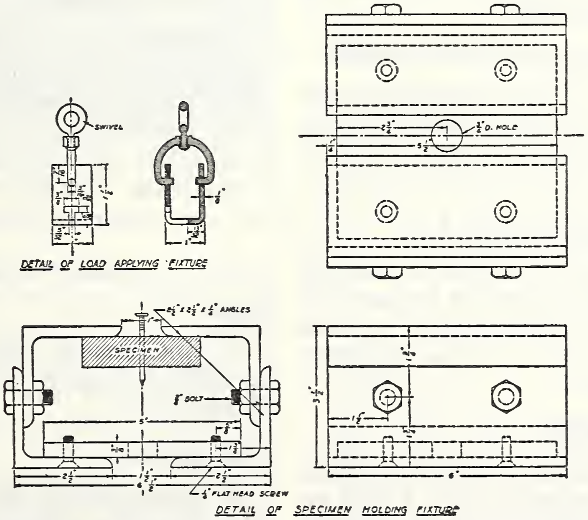

Fig. 9.—Detail of Testing Equipment for Measuring the Resistance of Nails to Direct Withdrawal.

23-65

NAIL-HEAD PULL-THROUGH TEST

Scope

46. Nail-head pull-through tests shall be made to measure the resistance of a building fiberboard to having the head of a nail or other fastener pulled through the board. This test is to simulate the condition encountered with forces that tend to pull paneling or sheathing from a wall.

Test Specimen

47. The test specimen shall be of convenient size (at least 3 in. (7.5 cm) in width by 6 in. (15 cm) in length). Common wire nails 0.113 in. (2.80 mm) in diameter shall be driven through the board with the head set flush with the surface of the board (Notes 1 and 2) at right angles to the face. The thickness of each specimen shall be measured to an accuracy of not less than ±0.3 per cent.

NOTE 1.—A sixpenny common wire nail meets this requirement.

NOTE 2.—For interior applications, the resistance to pull-through of a finishing nail may be preferred. For other applications, some special fastener like a staple or roofing nail may be desired instead of the common nail. If for any reason a different fastener than the common nail is used, the report of the test shall describe the fastener actually used.

Specimens Tested in the Dry Condition

48. When tests are made in the dry state, the pull-through shall be made immediately after the nails have been driven.

Specimens Soaked Before Test

49. Specimens to be tested in the soaked condition shall be prepared in accordance with Section 12, and the nails shall be driven before the specimens are soaked.

Method of Loading

50. The assembly for the direct withdrawal test detailed in Fig. 9 shall be modified by replacing the top pair of angles in the specimen-holding fixture with a 6-in. length of 6 by $2\frac{1}{4}$-in. American standard channel. The web of the channel shall have a 3-in. diameter opening centered in the web. The edge of this opening provides the support to the specimen during test. The specimen-holding fixture shall be centered and attached to the lower platen of the testing machine. The specimen shall be inserted in the holding fixture with the point of the nail up. The point of the nail shall be gripped by a tension grip or "Jacob's" type drill chuck which is attached to the upper platen of the testing machine with a universal joint or toggle linkage, to provide for automatic aligning. Loads shall be applied by separation of the platens of the testing machine. For other types of fasteners than nails, it may be necessary to modify the chuck or tension-grip type of loading fixture.

Speed of Testing

51. Load shall be applied to the specimen throughout the test by a uniform motion of the movable head of the testing machine at a rate of 0.06 in. (1.5 mm) per min. (see Note 1, Section 15).

Test Data and Report

52. The maximum load required to pull the head of the nail or other fastener through the board shall be the measure of the resistance of the material to nail-head pull-through, and shall be included in the report. The report shall describe the type of fastener used and the failure.

HARDNESS TEST

Scope

53. The modified Janka ball test shall be used for determining the hardness of fiberboards.

Test Specimen

54. Each specimen shall be nominally 3 in. (7.5 cm) in width and 6 in. (15 cm)

in length and at least 1 in. (2.5 cm) thick. Because most fiberboards are manufactured in thicknesses of less than 1 in. (2.5 cm), the specimen for test shall be made by bonding together several layers of the fiberboard to make the required thickness. A rubber cement or other suitable flexible adhesive shall be used. The finished specimen shall be trimmed after bonding so that edges are smooth. The dimensions of the specimens as tested shall be measured to an accuracy of not less than ±0.3 per cent.

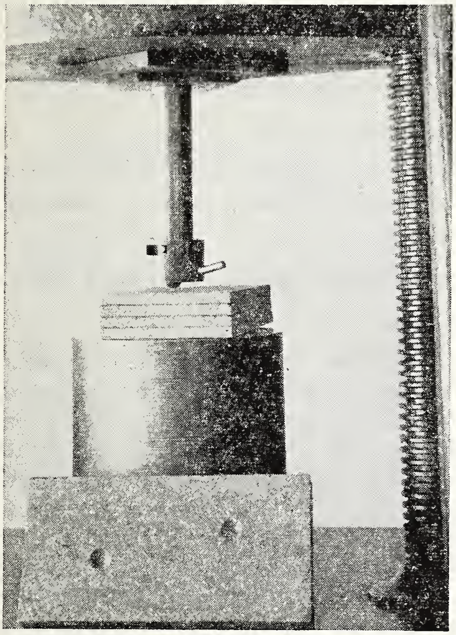

FIG. 10.—Janka Ball Test Apparatus for Hardness of Fiberboards.

Method of Test

55. The modified ball test with a "ball" 0.444 in. (1.13 cm) in diameter (1 sq cm projected area) shall be used for determining hardness. The load at which the "ball" has penetrated to one half its diameter, as determined by an electric circuit indicator or by the tightening of the collar against the specimen, shall be recorded as the measure of hardness. The test assembly with a tool of the tightening collar type is shown in Fig. 10.

Number of Penetrations

56. Two penetrations shall be made on each of the two flat faces of the fiberboard. Where one face is different than the other, as for example the smooth face and wire-textured back of most hardboards, the data obtained from the two faces shall be reported separately. The locations of the points of penetration shall be at least 1 in. (2.5 cm) from the edges and ends of the specimen and far enough apart so that one penetration will not affect another one.

Speed of Testing

57. The load shall be applied continuously throughout the test at a uniform rate of motion of the movable crosshead of the testing machine of 0.25 in. (6 mm) per min (see Note 1, Section 15).

Test Data and Report

58. The maximum load required to embed the "ball" to one half its diameter shall be the measure of hardness, and shall be included in the report.

SHEAR STRENGTH IN THE PLANE OF THE BOARD

Scope

59. Shear strength tests shall be made on specimens prepared by laminating each specimen so that the plane of the shear failure will be in the board proper and not in the glue lines. This test, except for the method of preparing the specimen, follows the procedure described in Sections 88 to 92 of the Methods of Testing Small Clear Specimens of Timber (ASTM Designation: D 143).[4]

Test Specimen

60. The shear-parallel-to-plane of board tests shall be made on 2 by 2 by

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[4] Appears in this publication, see Contents in Numeric Sequence of ASTM Designations at front of book.

2½-in. (5 by 5 by 7.5-cm) specimens notched as illustrated in Fig. 11. It is the intent in this test to have the plane of shear parallel to the surfaces of the board and to have the failure approximately midway between the two surfaces of the board. The specimen shall be glued up by laminating sufficient thicknesses (Note) of the board together to produce the desired 2-in. thickness of specimen as shown in Fig. 11. The actual area of the shear surface shall be measured.

NOTE.—When the shear strength of a thin board like hardboard is desired, it will be permissible to use a thicker material such as plywood for outer laminations to reduce the total amount of gluing. When that procedure is used, at least the center lamination and preferably the three center laminations shall be of the board under test.

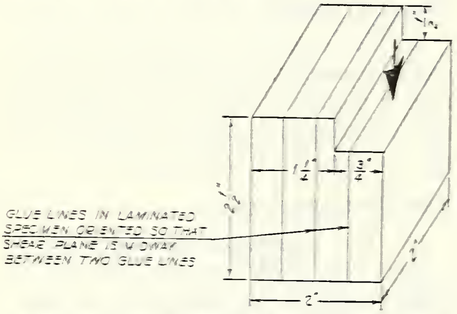
1¼"
¾"
2½"
GLUE LINES IN LAMINATED SPECIMEN ORIENTED SO THAT SHEAR PLANE IS MIDWAY BETWEEN TWO GLUE LINES
2"
2"

FIG. 11.—Shear Parallel to Surface Test Specimen.

Procedure

61. A shear tool similar to that illustrated in Fig. 17 of Methods D 143, providing a ⅛-in. offset between the inner edge of the supporting surface and the plane, along which failure occurs, shall be used. The load shall be applied to, and the specimen supported on, the ends of the specimens as indicated by the large arrow in Fig. 11. Care shall be taken in placing the specimen in the shear tool to see that the crossbar is adjusted so that the edges of the specimen are vertical and the end rests evenly on the support over the contact area. The maximum load only shall be observed.

Speed of Testing

62. The load shall be applied continuously throughout the test at a rate of motion of the movable crosshead of 0.024 in. (0.6 mm) per min (see Note 1, Section 15).

Test Failures

63. The character and type of failure shall be recorded. In all cases where the failure at the base of the specimen extends back onto the supporting surface, the test shall be culled.

Moisture Content

64. The portion of the specimen that is sheared off shall be used as a moisture specimen.

GLUE-LINE SHEAR TEST (BLOCK TYPE)

Scope

65. The block-type glue-line shear test shall be used to evaluate glued board constructions such as are obtained when thicknesses are laminated together to provide a greater thickness than when manufactured. When desired, the specimen may be modified to evaluate glue lines between fiberboard and solid wood or veneer by laminating the specimen so that the glue line to be evaluated is so oriented in the specimen that it coincides with the plane of shear in the specimen. This test procedure is adapted from the "Glue Block Shear Test," Sections 63 to 67 of the Methods of Testing Veneer, Plywood, and Other Glued Veneer Constructions (ASTM Designation: D 805).[4]

Test Specimen

66. The test specimen shall be 2 in. (5 cm) in width and 2 in. (5 cm) in height, and shall be fabricated as shown in

Fig. 12. The specimen shall be from 1 to 2 in. (2.5 to 5 cm) thick, as necessary, depending on the thickness of the board (Note). Specimens shall be sawed from panels glued up in sizes of at least 6 in. square. Care shall be taken in preparing test specimens to make the loaded surfaces smooth and parallel to each other and perpendicular to the glue line in the shear plane. Care shall be exercised in reducing the lengths of the laminations to $1\frac{3}{4}$ in. to insure that the saw cuts extend to, but not beyond the glue line. The width and height of the specimen at the glue line shall be measured to at least the nearest 0.01 in. These measurements shall determine the shear area.

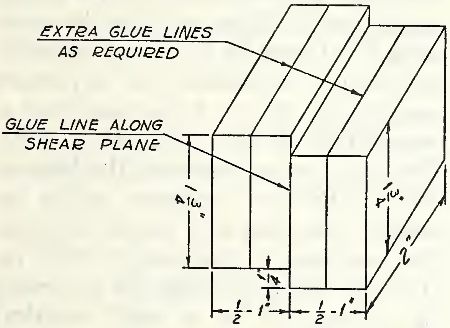

FIG. 12.—Block-Type Glue-Line Shear Test Specimen.

NOTE.—When the glue-line shear strength of a thin board like hardboard is desired, it will be permissible to use a thicker material such as plywood for outer laminations to reduce the total amount of gluing. The material on either side of the glue line in the plane of shear shall be the board under test unless the test involves a glue line of board and another material.

Loading Procedure

67. The load shall be applied through a self-aligning seat to insure uniform lateral distribution of load. The load shall be applied with a continuous motion of the movable head of the testing machine at a rate of 0.024 in. (0.6 mm) per min. The loading tool required for the shear in the plane of the board test, adjusted so that failure will occur along or adjacent to the glue line (no offset), shall be used to load the specimen. The shear tool is shown in detail in Fig. 18 of Methods D 805.

Test Failures

68. The shear stress at failure, based on the maximum load, the overlap area between the two laminations, and the percentage of fiber failure, shall be reported for each specimen.

WATER ABSORPTION

Scope

69. A test shall be made to determine the water-absorption characteristics of building boards.

Test Specimen

70. The test specimen shall be 12 by 12 in. (30 by 30 cm) in size, or 6 by 6 in. (15 by 15 cm) in size with all four edges smoothly and squarely trimmed.

Conditioning Prior to Test

71. The test specimen shall be conditioned as nearly as deemed practical to constant weight and moisture content in a conditioning chamber maintained at a relative humidity of 65 ± 1 per cent and a temperature of 20 ± 3 C (68 ± 6 F). The moisture content after conditioning shall be reported.

Weight and Volume of Test Specimen

72. After conditioning, the specimen shall be weighed to an accuracy of not less than ±0.2 per cent and the width, length, and thickness shall be measured to an accuracy of not less than ±0.3 per cent. The volume of the specimen shall be computed from these measurements.

Submersion in Water

73. The specimen shall then be submerged vertically in distilled water maintained at a temperature of 20 ± 1 C (68 ± 2 F). As an alternate to the above

method of submersion, specimens may be submerged horizontally under 1 in. (25 mm) of water. After a 2-hr submersion, the specimen shall be suspended to drain for 10 min, at the end of which time the excess surface water shall be removed and the specimen immediately weighed. The specimen shall then be submerged for an additional period of 22 hr and the above weighing procedure repeated.

Drying After Submersion

74. After submersion the specimen shall be dried in an oven at 103 ± 2 C as outlined in Sections 86 and 87, and the moisture contents (based on oven-dry weight) calculated from the weights after conditioning and after 2- and 24-hr submersion.

Calculation and Report

75. The amount of water absorbed shall be calculated from the increase in weight of the specimen during the submersion, and the water absorption shall be expressed both as the percentage by volume and by weight based on the volume and the weight, respectively, after conditioning. The specific gravity of the water shall be assumed to be 1.00 for this purpose.

LINEAR VARIATION WITH CHANGE IN MOISTURE CONTENT

Scope

76. Tests of linear variation with change in moisture content shall be made to measure the dimensional stability of a fiberboard with change in moisture content.

Test Specimen

77. The test specimens, when possible, shall be 3 in. (7.5 cm) in width and at least 12 in. (30 cm) in length. Two specimens shall be provided, one cut parallel with the long dimension of each board and one from the same board cut at right angles to the long dimension. When a board does not permit obtaining a 12-in. (30-cm) specimen, the maximum length possible shall be used, but it shall be at least 6 in. (15 cm).

Procedure

78. (*a*) The following or any more accurate procedure shall be followed for measuring specimens: At each of two points approximately 10 in. (25 cm) apart on the center line of each specimen, coat a small area by rubbing with a glass-marking pencil (or wax crayon). When smaller specimens are used, the distance between marks shall be the maximum possible. Make a fine cross with a razor blade on the center line in each of these two areas as reference points for length measurements. Then condition the specimens for at least 24 hr or until practical equilibrium is obtained at a relative humidity of 50 ± 1 per cent and a temperature of 20 ± 3 C (68 ± 6 F). Then make measurements of the distance between the two reference points by means of the scale and magnifying lens. Take readings to the nearest 0.005 in. (0.1 mm). Then condition the specimens for at least 24 hr or until practical equilibrium is obtained at a relative humidity of 90 ± 5 per cent and a temperature of 20 ± 3 C (68 ± 6 F), after which measure again the distance between the two reference points. Make the measurements in the conditioned air specified in each case, or as quickly as possible after the specimen is removed therefrom.

NOTE.—Where values of linear expansion associated with exposure to a greater humidity change are desired, equilibrium at a relative humidity of 30 ± 1 per cent may be used for the lower humidity condition rather than the 50 per cent specified in Section 78. The report shall state the actual humidity conditions used.

(*b*) Because the linear variation with change in moisture content of fiberboards is relatively small (usually less than 1 per cent), it is important that as accurate a method as possible be used to measure length. A more accurate and convenient method than the one described above for determining the linear variation with change in moisture content is by means of a dial gage comparator measuring the over-all length of the specimen to 0.001 in. (0.02 mm) (see Figs. 13 and 14). For this type of measurement, the sides and ends of the specimen shall be square and smoothly cut. Care must be exercised when measuring to hold the specimen flat and to orient it in the dial gage comparator the same way each time a measurement is made.

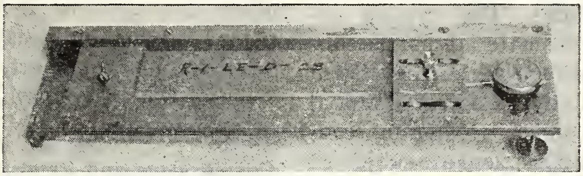

Fig. 13.—Dial Gage Comparator for Determining Linear Variation of Fiberboard with Change in Moisture Content.

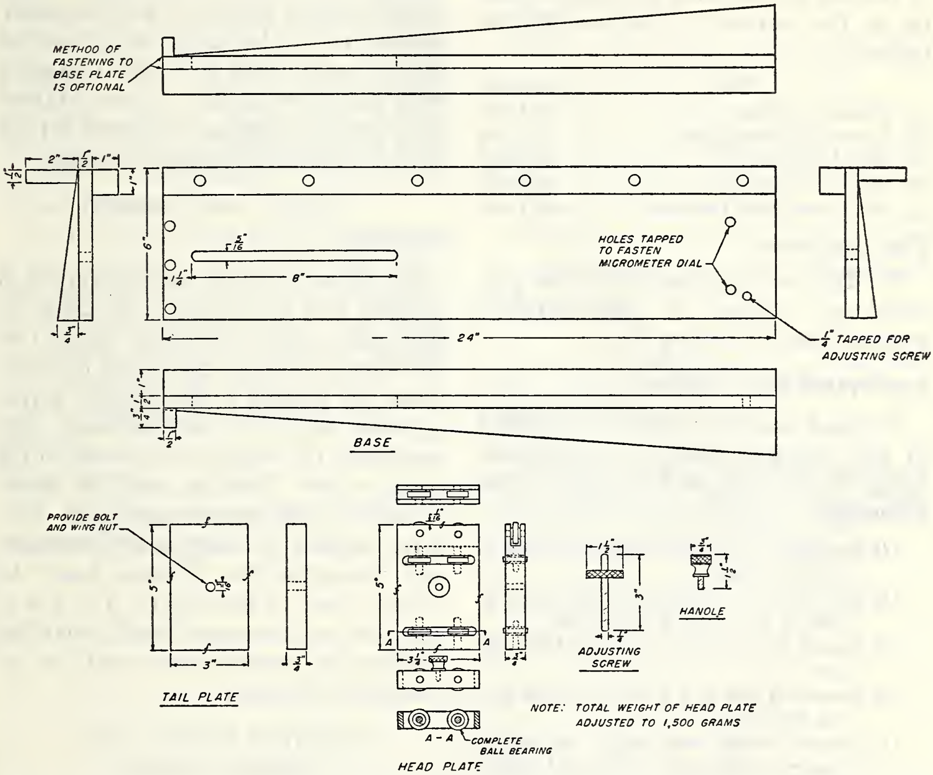
METHOD OF FASTENING TO BASE PLATE IS OPTIONAL
2"
1/2
1"
1/2
1"
6"
5/16
1/4
8"
3/4
24"
HOLES TAPPED TO FASTEN MICROMETER DIAL
1/4" TAPPED FOR ADJUSTING SCREW
1"
1/2
3/4
1/2
BASE
PROVIDE BOLT AND WING NUT
5"
3"
3/4
TAIL PLATE
1/16
5"
A
A
3 1/2
3/4
A - A
COMPLETE BALL BEARING
HEAD PLATE
1 1/2
3"
1/4
ADJUSTING SCREW
5/8
1 1/2
HANDLE
NOTE: TOTAL WEIGHT OF HEAD PLATE ADJUSTED TO 1,500 GRAMS

Fig. 14.—Details of Dial Gage Comparator for Measuring Linear Variation of Fiberboard with Change in Moisture Content.

Calculation and Report

79. The linear variation with change in moisture content shall be reported as the percentage change in length between the reference marks based on the length at 50 per cent relative humidity.

ACCELERATED AGING

Scope

80. The accelerated aging test shall be used to obtain a measure of the inherent ability of a material to withstand severe exposure conditions. The cycling exposure to which the material shall be subjected is a simulated condition developed to determine relatively how a material will stand up under weathering conditions. After the specimens are subjected to the cycles of accelerated aging given in Section 82, test shall be made according to the methods of test outlined as follows:

Test	Sections
(*1*) Static Bending	10 to 19
(*2*) Lateral Nail Resistance	33 to 38
(*3*) Nail Withdrawal	39 to 45
(*4*) Water Absorption	69 to 75
(*5*) Nail Head Pull-Through	46 to 52

Test Specimens

81. The test specimens shall be prepared as specified in the pertinent sections listed in Section 80.

Accelerated Aging Cycles

82. Each specimen shall be subjected to six complete cycles of accelerated aging. Each cycle shall consist of the following:

(*1*) Immersed in water at 120 ± 3 F (49 ± 2 C) for 1 hr.
(*2*) Sprayed with steam and water vapor at 200 ± 5 F (93 ± 3 C) for 3 hr.
(*3*) Stored at 10 ± 5 F (−12 ± 3 C) for 20 hr.
(*4*) Heated at 210 ± 3 F (99 ± 2 C) in dry air for 3 hr.
(*5*) Sprayed again with steam and water vapor at 200 ± 5 F (93 ± 3 C) for 3 hr.
(*6*) Heated in dry air at 210 ± 3 F (99 ± 2 C) for 18 hr.

After the completion of the six cycles of exposure, the material for test shall be further conditioned at a temperature of 20 ± 3 C (68 ± 6 F) and a relative humidity of 65 ± 1 per cent for at least 48 hr before test.

Inspection of Material During Cyclic Exposure

83. Frequent inspections of the material shall be made during the aging cycles for any signs of delamination or other disintegration. If there is any apparent damage to the material, it shall be described in the report, as well as the stage of the cycle in which the damage became apparent.

Comparisons and Report

84. After the tests following the accelerated aging treatment are completed, the results shall be calculated as specified in the appropriate test and compared with the corresponding values obtained from tests made on material that did not have the accelerated aging treatment.

CUPPING AND TWISTING

Procedure

85. When required, measurements of cupping and twisting may be made on specimens after accelerated aging (see Sections 80 to 84). Cupping may be determined by placing a straightedge across opposite edges of the specimen, and measuring the maximum distance to the concave face. Twisting may be determined by placing the specimen with three corners touching a level surface, and measuring the distance from the raised corner to the surface. The size of specimen and necessary details regarding methods of measurements shall be included in the report.

MOISTURE CONTENT AND SPECIFIC GRAVITY

Procedure

86. (*a*) The specific gravity (or density) of each static bending specimen at time of test shall be determined from the dimensions, weight, and moisture content, as provided in Sections 8, 18, and 87. When specific gravity determinations are required on specimens of prism form

from other tests, like procedure may be used. The moisture content of a specimen may be determined from a coupon cut from the test specimen as in the static bending test, or the entire test specimen may be used for the moisture determination.

(*b*) When for any reason additional determinations of moisture content and specific gravity (or density) are required, separate samples for this determination shall be prepared from the same material as is used in preparing the test specimens. These moisture content and specific gravity specimens shall be the full thickness of the material and 3 in. (7.5 cm) wide and 6 in. (15 cm) long. Smaller specimens may be used when deemed necessary. The specimens shall be conditioned in accordance with the provisions of Section 4.

(*c*) The dimensions shall be measured to an accuracy of not less than ±0.3 per cent, and the weight to an accuracy of not less than ±0.2 per cent. The oven-dry weight shall be obtained after drying the specimen in an oven at 103 ± 2 C until approximately constant weight is attained.

Calculations

87. (*a*) The moisture content shall be calculated as follows:

$$M = 100\left(\frac{W - F}{F}\right)$$

where:

M = moisture content, in per cent,
W = initial weight, and
F = final weight when oven-dry.

(*b*) The specific gravity shall be calculated as follows (Note):

$$\text{Sp gr} = \frac{KF}{Lwt}$$

where:

F = final weight when oven dry, grams,
L = length of coupon, in. (or cm),
w = width of coupon, in. (or cm),
t = thickness of coupon, in. (or cm), and
K = 1, when metric units of weight and measurement are used; or 0.061, when metric units of weight and English units of measurement are used.

NOTE.—The specific gravity as determined by this equation is based on volume at test and weight when oven dry.

(*c*) When desired, the density based on weight and volume of the specimens after conditioning may be calculated.

APPROVED AS
AMERICAN STANDARD
BY THE AMERICAN STANDARDS ASSOCIATION
ASA NO.: O4.2-1927 (R 1958)
UDC 691.11:620.1

Standard Methods of
STATIC TESTS OF TIMBERS IN STRUCTURAL SIZES[1]

ASTM Designation: D 198 - 27

ADOPTED, 1927.[2]

Reapproved in 1958 Without Change.

This Standard of the American Society for Testing Materials is issued under the fixed designation D 198; the final number indicates the year of original adoption as standard or, in the case of revision, the year of last revision.

Although numerous tests of timber in structural sizes have been made for various purposes, there has been a general lack of uniformity of test procedure. Consequently, it has not been possible to correlate data from different sources, nor have the results obtained by different investigators contributed their full measure of usefulness toward an increasing fund of knowledge. Study and experience have shown the extent to which various factors, such as loading appliances, rate of loading, etc., influence test results, and it is with the thought of standardizing these and other factors that this test procedure is prepared. The plan has been to cover very definitely the tests of certain types of timbers such as bridge stringers and joists and at the same time to suggest procedure. so far as possible, for other structural timber forms. Summarized, the underlying purpose is the establishment of practice which will afford uniform results of the greatest ultimate value from all tests of timbers and at the same time permit the correlation of data so far as possible with existing data on timbers of certain species.

It is not the intention to discourage the use of methods other than those herein prescribed whenever the testing problem is of such nature as to warrant their application. However, experience has emphasized the importance of the requirements that have been specified in these methods, and variations in apparently minor details will often seriously affect the data obtained. It is recommended that any variations from the methods herein prescribed shall be recorded.

The field of timber testing is so broad, and involves so many objectives, particularly when built-up or manufactured articles are considered, that it is obviously difficult, if not impossible, to formulate correct procedure for all such cases. Ample opportunity, therefore, still awaits the application of initiative to special testing problems and promotion of progress in the art. It is hoped, however, that the principles incorporated in these methods will at least serve to some extent as a guide in tests of even a special nature.

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[1] Under the standardization procedure of the Society, these methods are under the jurisdiction of the A.S.T.M. Committee D-7 on Wood.

[2] Prior to adoption as standard, these methods were published as tentative from 1924 to 1927.

The test methods presented are the outgrowth of years of experience and research, largely on the part of the United States Forest Service. Such sample data forms are included as were thought helpful to investigators in systematizing records. No attempt has been made to cover methods of computation or analysis, as these were considered to lie outside the scope of the standard. Data properly recorded can be analyzed at will, but fundamental differences in test procedure present a barrier beyond which analysis and correlation of results cannot proceed with any degree of assurance.

Purpose of Tests

1. Tests of timbers in structural sizes are made to afford:

(*a*) Data upon which to base the formulation of grading rules and specifications.

(*b*) Data upon which to establish the relation between the strength properties of structural timbers and of small clear specimens cut from them, and for use in the establishment of allowable stresses.

(*c*) Data as to the influence of defects on the mechanical properties of timbers.

(*d*) Data on the strength properties of different species in structural sizes.

(*e*) Data for use in checking existing formulas relating to structural timbers.

(*f*) Data as to the influence of seasoning on the mechanical properties.

(*g*) Data as to the effect of form and shape of specimen on the properties.

(*h*) Data as to the influence of preservatives and methods of preservative treatment on the mechanical properties.

Classes of Tests

2. In general, tests of timbers are divided into two classes, as follows:

(*a*) Major tests, that is, tests of principal members under investigation.

(*b*) Minor tests, that is, tests of small clear specimens cut from the principal members.

Kind of Tests

3. (*a*) The principal tests of such structural timbers as bridge stringers or joists are:

Static bending,
Compression parallel to grain, and
Compression perpendicular to grain.

(*b*) The accompanying minor tests on small clear specimens are:

Static bending,
Compression parallel to grain,
Compression perpendicular to grain,
Hardness, and
Shear parallel to grain.

COLLECTION OF MATERIAL

Selection

Authentic Identification

4. The material for test shall be selected by one qualified to identify the species.

Procedure for Bridge Stringers, Joists, etc.

5. In any given case, the number of test specimens shall be determined from due consideration of the purpose in mind, since definite instructions cannot be given to cover all cases. The following procedure applies particularly to full-size timbers, such as bridge stringers and joists, and incidentally to other types, as fabricated beams, to which special reference will be made in paragraphs set in smaller type.

Number and Size of Major Specimens

6. (*a*) For tests of timbers of any given species in structural sizes, such as bridge stringers, requiring a range in grade of material, at least forty 32-ft. or eighty 16-ft. green unsurfaced timbers should be selected in a manner that will provide representative material. The length of specimens required for test is

dependent upon the depth. For suggested lengths of timbers other than bridge stringers, see Section 22 (*b*), (*c*), and (*d*).

(*b*) Timbers 8 by 16 in. or 6 by 12 in. in nominal cross-section are especially recommended.

Selection and Matching of Specimens

7. Each 32-ft. timber shall be cut in half to furnish one 16-ft. specimen to be tested green and one to be tested air-dry, thus affording end matching. Where only 16-ft. material is available, the timbers shall be selected and matched in pairs, one timber to be tested green and the other to be tested air-dry. In matching these 16-ft. timbers all factors influencing their strength should, so far as practicable, be considered. Some of the most important factors are density, rate of growth, direction of grain (straight, diagonal, or spiral), character and location of defects (such as knots, checks, etc.), position of specimen in tree with respect to cross-section or height, and the characteristics of individual trees.

Field Marking

Butt Designation

8. At the time of selection a mark shall be made on each timber to designate the butt end.

Shipment Number

9. All material collected at a given source and shipped at one time shall be given a shipment number or other designation which shall be incorporated in the test records.

Field Descriptions

Field Descriptions

10. Field notes fully describing the material shall be carefully made by the collector. These notes shall, so far as possible, supply data as outlined in Table I and shall be forwarded for incorporation in the record.

TABLE I.—SHIPMENT DESCRIPTION FIELD NOTES.

Project No., *XC*
Tree No., *1*
Locality cut: State, *Florida*
Township, *T3N: R25E*
Slope, *Level.* Absolute elevation, *38 ft.*
Undergrowth, *Small amount—scattered*
Height, *110 ft.* Seedling or sprout, *Seedling*
Crown, *Large, well developed*
Stem, *Clear, straight*
How and when transported from woods, *By wagon, May, 1914*

Shipment No., *012*
Species, *Longleaf pine*
County, *Nassau*
Date cut, *April, 1914*
Aspect, ...
Soil, *Sandy*
Age, *241 years*
D.B.H., *26 in.*
Date sawed, *May 12, 1914*

LIST OF SPECIMENS.

Piece No.	Size of Specimens			Volume, cu. ft.	Footage, b. m.	Weight, lb. (Show date)
	Length, ft.	Width, in.	Depth, in.			
1	16.10	7.50	15.50	13.00	171	660

REMARKS: Note any other special points which would be of value.

Preparation for and Records of Shipment

Preparation for Shipment

11. (*a*) The ends of all green timbers shall be given a coating of paint or other suitable substance to retard end drying and end checking, care being taken to retain the butt designation. They shall be close-piled, and before and during shipment shall be kept covered with damp shavings or other substance to prevent drying. If conditions are particularly favorable to the development of molds, stains, or decay, the specimens shall first be brushed or sprayed with a dilute solution of copper sulfate, or similar toxic solution.

(*b*) Record shall be made of the shipment routing, bill of lading, kind of shipment, date of shipment, and condition of material when shipped.

(*c*) Record shall also be made of date of receipt of shipment at destination, its condition and the method of storage. The time elapsing between the sawing of green timbers and their testing should be reduced to a minimum.

DISPOSITION OF MATERIAL AT DESTINATION

Grouping

12. When the material arrives at the testing laboratory, it shall be divided into two matched groups of timbers of approximately like quality as specified in Section 7, one portion to be tested green and the other to be weighed and placed under cover for air seasoning prior to testing. After the 32-ft. timbers have been cut into 16-ft. lengths, the specimens to be air-dried shall be selected alternately from butt and top cuts.

Marking

13. The butt end of each 16-ft. specimen shall be designated "*A*" and the top end "*B*". Other symbols shall be given to each timber in classifying it as to density, position in tree, defects, or other factors that are under consideration. The minor test specimens and data forms shall carry such of these symbols as may be necessary to identify them fully.

Storage

14. (*a*) The material to be tested green shall be close-piled on skids which are free from contact with the soil, and shall be kept covered. It shall not be held long enough to permit seasoning[3] or damage from checking, decay, or insect attack.

(*b*) The ends of the specimens to be air-dried shall, if necessary, be given a suitable coat of pitch, paint, or other substance to retard checking. The specimens shall be open-piled in a place allowing free access and circulation of air, but shall be protected from sunshine, rain, snow, and moisture from the ground and shall not be subjected to artificial heat.

(*c*) All of the timbers to be air-dried shall be weighed when stored and at sufficiently frequent intervals thereafter to afford accurate data on the progress of seasoning. No material shall be considered thoroughly air-dry and fully conditioned for testing until practically constant weight has been reached.[4] (Wood absorbs and gives off moisture with changing atmospheric conditions; consequently it never comes to absolutely constant weight.)

(*d*) When properly seasoned, the timbers shall be surfaced on four sides before being tested.

KIND AND NUMBER OF TESTS

Specimens for Major Tests[5]

15. (*a*) *Major Bending.*—The structural member proper shall be tested as a beam. (See Sections 19 to 30.)

(*b*) *Compression Perpendicular to Grain.*—A section 60 in. long shall be cut from the "*A*" or butt end of each beam after test, except when end "*A*" fails by shear in the bending test, in which case the section shall be taken from the "*B*" or top end. A specimen 30 in. long for compression-perpendicular-to-grain test shall be cut from that end of the 60-in. piece which is nearer the point of loading.

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[3] The many factors which influence the rate of seasoning, such as species, moisture content, and diverse climatic differences, preclude the establishment of a definite limit of loss in weight which may be permitted in green material prior to test.

[4] A desirable condition for testing air-day material in small sizes may be considered as about 12 per cent moisture content. Large timbers, such as bridge stringers, however, usually dry slowly, but may be considered conditioned when, during the season of most rapid drying, successive weighings indicate the moisture content is as low as may reasonably be expected, with due consideration to the climatic conditions of the locality. Such seasoning may require from about one to four years.

[5] The procedure outlined utilizes to best advantage the entire major specimen and if carefully followed will not usually admit the inclusion of specimens which have been seriously strained in the major bending test. The compression specimens referred to in Sections 15(*b*) and (*c*) necessarily include such defects as are normal to the material under test.

(*c*) *Compression Parallel to Grain.*—Two compression-parallel-to-grain specimens, each 6 by 6 by 24 in., shall be taken from the farther end of the 60-in. piece specified in Paragraph (*b*).

Specimens for Minor Tests[6]

16. (*a*) A 50-in. section shall be cut from the end of the beam opposite that required for the 60-in. specimen specified in Section 15 (*b*). Six 2 by 2 by 50-in. sticks shall be taken from this piece. In case defects make it difficult to obtain certain of the other clear specimens hereinafter provided for, they may be secured from the uninjured portion of the minor static bending specimens after the test covered in Paragraph (*b*).

(*b*) *Static Bending.*—Six static bending specimens free from defects shall be taken, one from each of the 50-in. sticks specified in Paragraph (*a*).

(*c*) *Compression Parallel to Grain.*—Six compression-parallel-to-grain specimens free from defects shall be taken, one from each of the 50-in. sticks specified in Paragraph (*a*).

(*d*) *Compression Perpendicular to Grain.*—Three compression-perpendicular-to-grain specimens free from defects shall be taken, one from each of three of the 50-in. sticks specified in Paragraph (*a*).

(*e*) *Hardness.*—Three hardness specimens free from defects shall be taken, one from each of three of the 50-in. sticks specified in Paragraph (*a*) other than those from which the specimens specified in Paragraph (*d*) are taken.

(*f*) *Shear Parallel to Grain.*—Twelve shear specimens free from defects shall be cut, two from each of the 50-in. sticks specified in Paragraph (*a*). One specimen from each pair taken from the same stick shall be tested in radial shear (surface of failure radial to growth rings) and the other in tangential shear (surface of failure tangential to growth rings).

Photographs of Timbers

17. All air-dried timbers shall be photographed on four sides both before and after test. All green timbers shall be photographed on four sides after test only. The middle of the length of the beam, the load and support points, and the order of occurrence of the failures shall be indicated so as to show in the photograph; if necessary to bring them out in the photograph the failures should be penciled or pointed.

MOISTURE CONTROL

Control of Moisture Content

18. (*a*) As specified in Section 14 (*c*), the major specimens to be tested in the air-dry condition shall be brought to practically constant weight before test. All tests shall be carried out in such a manner as to prevent large changes in moisture content.

(*b*) All minor specimens shall be tested immediately after cutting from the majors to prevent change in moisture content.

STATIC BENDING TEST OF STRUCTURAL SIZE TIMBER

Size and Weight

19. (*a*) The beam shall be weighed before test. The length and the actual depth and width at the center shall be measured.

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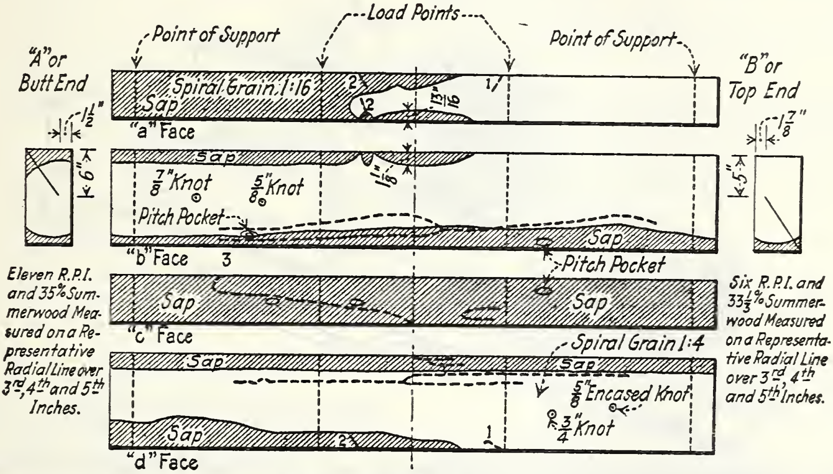
[6] The procedure outlined utilizes to best advantage the entire major specimen and if carefully followed will not usually admit the inclusion of specimens which have been seriously strained in the major bending test. As specified in Section 26 of the Standard Methods of Testing Small Clear Specimens of Timber (A.S.T.M. Designation: D 143), see p. 1, the minors selected shall be free from defects which will affect the properties under consideration.

(*b*) For nonrectangular beams or beams nonuniform in section, data shall be secured from which the exact size and shape of the section at any point throughout the length may be obtained.

Additional Marking

20. In addition to the markings previously made, the four faces shall be lettered "*a*," "*b*," "*c*," and "*d*," beginning with *a* for the face to which the load is applied and proceeding successively to the right (clockwise) when viewed from the "*A*" or butt end of the timber.



NOTE.—Broken lines indicate test failures, and the accompanying numbers, their order of occurrence.

FIG. 1.—Sketch of Structural Size Timber Showing Method of Recording Location and Type of Defects and Other Pertinent Data.

Sketch of Beam

21. As part of the record, a sketch shall be made of the faces and ends of each beam showing the size, location, and type of defects, including cross-grain,[7] the distribution of sapwood and heartwood, the location of pith, when present, and the direction of the annual rings (see Fig. 1).[8] Detailed record shall also be made of other defects which may be present, such as crook, bow, cup, and twist.[9] The number of rings per inch and proportion of summerwood at both ends shall also be recorded.

Loading, Span, and Supports

22. (*a*) For timbers in structural sizes such as bridge stringers and joists, third-point loading over a span length of 15 ft. shall be used. Knife-edges rigidly attached to an auxiliary beam which in turn is hinged by a knife-edge shall be used in applying the load. The supporting knife-edges shall preferably be of the half-rocker type, and shall be so placed as to rock outward. To prevent accident or damage from their being thrust suddenly outward on failure of the specimen, they should be tied together by means of a slack chain or cable. Metal bearing plates 6 in. in

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[7] Cross-grained wood is that in which the wood cells or fibers do not run parallel with the axis of the piece. Cross-grain may be classified as spiral, diagonal, dip, wavy, curly, and interlocking. Definitions of these terms may be found in the Standard Definitions of Terms Relating to Timber (A.S.T.M. Designation: D 9), see p. 164. The presence of diagonal and spiral grain is usually indicated by surface checks; these invariably follow the direction of the grain. The amount of cross-grain in any portion of a timber may be expressed by the slope of the fibers (or checks) on each face with respect to the edges of the piece. Thus, a slope of 1 in 10 indicates a departure of the fibers from the direction of the axis of the specimen of 1 in. in 10 in. of length.

[8] Cross-section paper or quadrille-ruled note book paper is recommended for conveniently making this sketch of the beam to scale.

[9] For definitions of these terms, see U. S. Department of Agriculture *Circular No. 296*, p. 65.

width and not less than $\frac{1}{2}$ in. in thickness and extending entirely across the face of the beam shall be used over the supporting knife-edges. (See Fig. 2.)

(*b*) When beams are tested with respect to particular uses, the dimensions shall be such as to simulate actual conditions as closely as practicable.

(*c*) Fabricated beams such as I or box types shall be full size or solid at the loading points without abrupt change from the solid to the normal beam section.

(*d*) Center loading shall not be used for beams over 4 in. in depth when the span-depth ratio is 14 or less.

specified for third-point loading under Paragraph (*a*).

(*c*) Whenever possible, span-depth ratios between 11 and 15 shall be used. For span-depth ratios less than 14, the radius of curvature of the bearing blocks shall be proportionally increased over that specified in Paragraphs (*a*) and (*b*).

(*d*) Bearing blocks of the form and size shown in Fig. 3 shall be used at the load points in testing timbers in structural sizes, such as 6 by 12-in. and 8 by 16-in. bridge stringers, on a 15-ft. span.

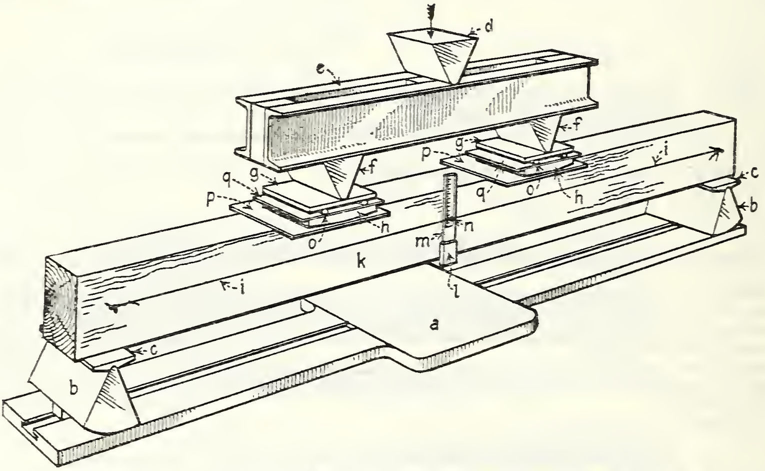

FIG. 2.—Diagrammatic Sketch Showing Method of Conducting Static Bending Test of Structural Sizes of Timber.

Bearing Blocks

23. (*a*) When testing beams under third-point loading on a span equal to 14 times the beam depth the load shall be applied through bearing blocks extending entirely across the face of the beam and having a radius of curvature three times the depth of the beam for a chord length at least equal to the depth of beam. Additional bearing may be obtained by continuing the curvature in both directions at a radius equal to twice the depth of the beam.

(*b*) For beams loaded at the center, the radius of the bearing block shall be one-half that

(*e*) When the depth of beam is greater than 4 in., a thin steel plate slightly wider than the beam shall be placed between the loading block and the beam. For beams up to 6 in. in depth, the thickness of this plate shall be from $\frac{3}{32}$ to $\frac{1}{8}$ in. For greater depth the thickness of plates shall be increased slightly to about $\frac{5}{32}$ in. for timbers 6 by 12 in. or 8 by 16 in. in cross-section.

(*f*) For fabricated sections such as airplane I and box beams up to 6 in. in depth, the plate shall be from $\frac{1}{16}$ to $\frac{3}{32}$ in. in thickness.

(*g*) Metal bearing plates and rollers shall be used between each bearing block and its corresponding knife-edge. The plates between rollers and knife-edges shall be not less than $1\frac{1}{4}$ in. in thickness. If the supporting knife-edges are of the full-rocker type rather than the half-rocker type recommended in Section 22 (*a*), rollers shall be placed under one loading knife-edge only.

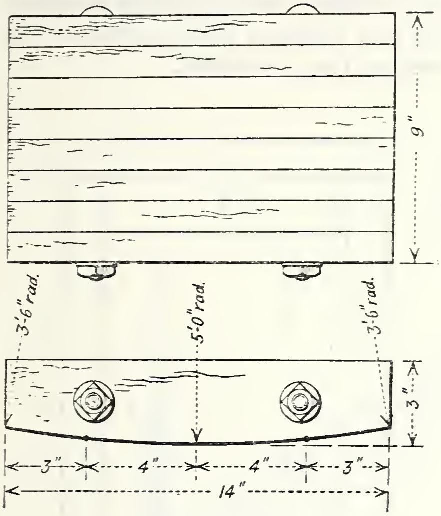

Fig. 3.—Details of Bearing Block for Timbers 12 to 16 in. in Depth When Tested in Third-Point Loading over 15-ft. Span.

Placement of Specimen in Machine

24. The beam shall be placed in the testing machine symmetrically with respect to the supports. Parallelism shall be obtained at bearing points. In the case of warped beams, wedges or shims shall be used between the plate and the loading or supporting knife-edges or both, as may be necessary to obtain an even bearing before the load is applied.[10] In the case of timbers containing defects, the load shall be applied to the poorer of the loading faces.

Speed of Testing

25. (*a*) The load shall be applied continuously, and with a uniform motion of the movable head throughout the test.

(*b*) *Case 1.*—Beams 4 in. or less in depth when containing defects, or 8 in. or less in depth when free from defects, shall be tested at a rate of fiber strain of 0.0015 in. per inch of outer fiber length per minute.[11]

Case 2.—Beams over 4 in. in depth when containing defects, or over 8 in. in depth when free from defects, shall be tested at a rate of fiber strain of 0.0007 in. per inch of outer fiber length per minute.[11]

(*c*) For two symmetrical concentrated loads the rate of motion of the movable head of the testing machine may be calculated from the formula:

$$N = \frac{z\,a}{3\,d}(3\,L - 4\,a)$$

where:

N = rate of motion of moving head in inches per minute,
z = unit rate of fiber strain in inches per inch of outer fiber length per minute,
a = distance from support to adjacent load in inches,
d = depth of beam in inches, and
L = span in inches.

For example, in testing beams 16 in. in depth under third-point loading and on a 15-ft. span, the rate of motion of movable head shall be 0.26 ± 0.065 in. per min.[11]

(*d*) For center loading, the rate of motion of the movable head of the testing machine may be calculated from the formula:

$$N = \frac{z\,L^2}{6\,d}$$

where the same legend applies as under Paragraph (*c*).

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[10] The use of shims or wedges is recommended in preference to planing because in certain cases the latter procedure may effect changes in section where undesirable.

[11] For permissible variation in rate of motion of movable head, see Section 51.

Load-Deflection Curves

26. (*a*) Load-deflection curves shall be plotted throughout the test.[12] The load and deflection at first failure, at the maximum load, and at points of sudden change shall be shown on the curve, although they may have to be interpolated because of not occurring at one of the regular load or deflection increments.

(*b*) The test shall be continued until the maximum load has been well passed. In the event of horizontal shear, the maximum load may occur after such failure.

Method of Determining Deflection

27. (*a*) Deflections of the beam at mid-height at the center of the span with respect to points at mid-height immediately above the supports shall be taken to the nearest 0.01 in.

(*b*) Deflection may be read directly by means of a wire stretched between nails driven at mid-height of the beam immediately above the supports and extending across a scale attached at mid-height at the center of the span. Figure 2 illustrates the method of test. A telescope or reading glass will be found useful in observing the deflections. When a reading glass is used parallax shall be prevented by placing a reflecting surface adjacent to the scale in order that the wire and its image may be made to coincide.

(*c*) Where special refinement is desired, deflection readings may be taken simultaneously on both sides of the beam, the wires (Paragraph (*b*)) being supported over free running pulleys and held taut with small suspended weights.

Description of Failures

28. The failures shall be described in detail as to type, manner and order of occurrence, and position in beam. The descriptions of the failures shall be suitably recorded and correlated with the load-deflection curves. The failures shall be sketched on the drawing of the beam referred to in Section 21, with notations as to the order of their occurrence. The section of the beam containing the failure shall be held for examination and reference until analysis of the data has been completed.

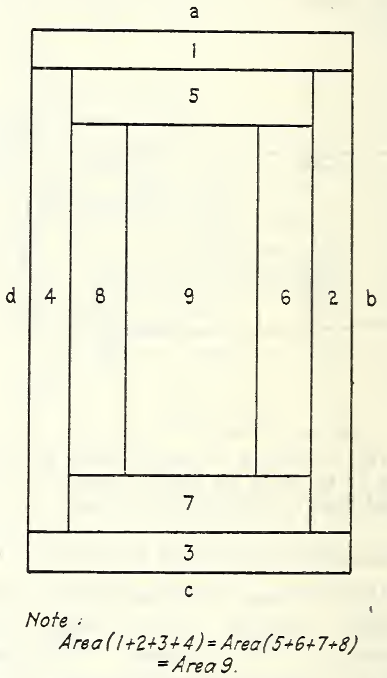

FIG. 4.—Cross-Section of Timber Showing Method of Cutting Up Moisture Distribution Sections.

Identification Sample

29. A section of the beam at least 2 in. in length shall be retained for purposes of identification and future reference. The number of rings per inch and proportion of summerwood shall be recorded for this section.

---

[12] See Fig. 1 of the Appendix for a sample static-bending data sheet and Fig. 2 of the Appendix for a sample computation data card.

Specimens for Moisture Determinations

30. Two sections 1 in. in length shall be cut from near the place of failure for moisture determinations. One of these shall be used for determining the average moisture content of the test specimen. The other, which may be termed a moisture-distribution section, shall be used for determining the moisture content of different portions of the cross-section and shall be sawed into parts according to the pattern shown in Fig. 4. Moisture determinations in each case shall be made in accordance with the procedure specified in Sections 44 to 48.

COMPRESSION PERPENDICULAR TO GRAIN

Size of Specimen

31. The compression-perpendicular-to-grain tests shall be made on specimens 30 in. in length and of the cross-section of the major beam. The actual width and length shall be measured and recorded, and all defects shall be described.

Loading

32. The load shall be applied through a metal plate 6 in. in width placed across a clear face of the specimen at the center of the length and at right angles to it. The load shall be applied to a face which corresponds to either the loading or supporting face of the static bending specimen. (Section 24.) (See Fig. 5.)

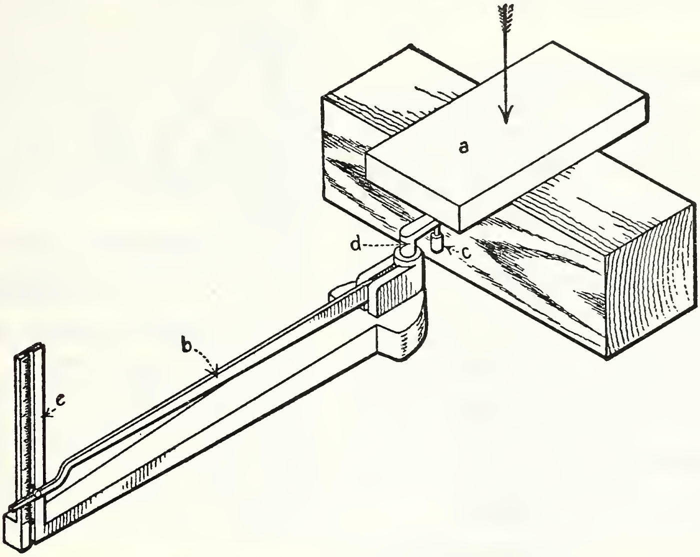

FIG. 5.—Diagrammatic Sketch of Method of Conducting Compression-Perpendicular-to-Grain Test

Speed of Testing

33. (*a*) The load shall be applied continuously throughout the test at a rate of motion of movable head[11] calculated from the formula:[13]

$$N = 0.0175\, d^{\frac{4}{9}}$$

where:

N = rate of motion of moving head in inches per minute, and

d = depth of beam in inches.

---

[13] Tests are now in progress to establish more definitely the proper rate of application of load; therefore, the requirement of this section may be changed on the completion of the study.

(*b*) For the specimens 8 by 16 in. in cross-section, for example, the rate of descent of the movable head shall be 0.060 ± 0.015 in. per min.[11]

Load-Compression Curves

34. Load-compression curves[14] shall be taken for all specimens until the elastic limit has been well passed, after which the test shall be discontinued. Compression readings shall be taken to 0.001 in.

Weight and Moisture Content

35. The specimen shall be weighed after test, and two sections shall be cut near the place of failure for moisture determinations. One of these shall be used for determining the average moisture content of the specimen. The other, which may be termed a moisture distribution section, shall be used for determining the moisture content of different portions of the cross-section and shall be sawed into parts according to the pattern shown in Fig. 4. Moisture determinations in each case shall be made in accordance with the procedure specified in Sections 44 to 48.

COMPRESSION PARALLEL TO GRAIN

Size of Specimen

36. The major compression-parallel-to-grain tests shall be made on the 6 by 6 by 24-in. specimens prepared from the pieces specified in Section 15 (*c*). The actual cross-section dimensions, the rate of growth, and the percentage of summerwood shall be determined and recorded for each specimen. All defects shall be described.

End Surfaces

37. Care shall be exercised in preparing the compression-parallel-to-grain test specimens to make the end surfaces plane, parallel, and normal to the axis of the specimen.[15]

Spherical Bearing

38. (*a*) A spherical bearing block shall be used to prevent eccentricity of loading. The radius of the sphere shall be as small as practicable, in order to facilitate adjustment of the bearing plate to the specimen. The suspended type of spherical bearing, to be used on top of the specimen, is especially recommended. The size of the compression plate shall be slightly larger than is necessary to encompass the end of the specimen when the latter is centered on the head.

(*b*) The adjustment of the suspended spherical bearing block may be accomplished by keeping the compression plate in motion about its bearing as contact is made with the specimen.

(*c*) In the spherical bearing block for use on the weighing table, adjustment shall be made by moving the bearing plate with the specimen centered thereon.

Speed of Testing

39. The load shall be applied continuously throughout the test at a rate of motion of the movable head of 0.036 ± 0.009 in. per min.[11]

Records

40. The maximum load obtained shall be recorded, together with a description and sketch of the failure. The section of the specimen containing the failure shall be held for examination and refer-

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[14] See Fig. 4 of the Appendix for a sample compression-perpendicular-to-grain data sheet and Fig. 3 of the Appendix for a sample computation data card.

[15] A sharp fine-toothed saw of either the cross-cut or "novelty" cross-cut type is indispensable for obtaining smooth end surfaces. Power equipment with accurate table guides is especially recommended for this work, though miter-box hand sawing is permissible. Hand planing of the ends, if carefully done, is sometimes advisable.

ence until analysis of the data has been completed.

Position of Test Failures

41. In order to obtain satisfactory and uniform results, the failures shall be made to develop in the body of the specimen. With specimens of uniform cross-section this may be obtained by having the ends properly prepared and dried to a slightly lower moisture content than the body. With green material, it will usually suffice to close-pile the specimens, cover the body with a damp or wet cloth, and expose the ends for a short time. For air-dry material it may sometimes be advisable, should the failures in test indicate that a slight end drying is necessary, to pile the specimens in a similar manner and place them in a desiccator.

Weight and Moisture Content

42. The specimen shall be weighed after test, and a moisture section shall be cut from the body of the piece near the failure. Moisture determinations shall be made in accordance with the procedure specified in Sections 44 to 48.

MINOR TESTS

Minor Test Procedures

43. The procedure for the conducting of minor tests shall conform to that prescribed in the Standard Methods of Testing Small Clear Specimens of Timber (A.S.T.M. Designation: D 143) of the American Society for Testing Materials.[16]

MOISTURE DETERMINATIONS

Selection of Samples

44. The samples for moisture determinations shall be selected as hereinbefore described for each test.

Cutting of "Distribution" Sample

45. The moisture-distribution specimens shall be cut into sections according to Fig. 4, as specified in Sections 30 and 35.

Weighing of Moisture Sample

46. Immediately upon obtaining any moisture sample, all loose splinters shall be removed and the sample weighed.

Drying

47. The moisture samples shall be open-piled in a ventilated oven and dried at a temperature which shall ultimately be increased to 98 ± 3 C. until constant weight is attained, after which the resulting weight shall be carefully determined and recorded as the oven-dry weight. For specimens not over 1 in. in length (in the direction of grain) continuous drying for about 48 hr. under the conditions specified is sufficient to bring the specimens to constant weight. For drying longer specimens, considerably more time will be required, since the rate of drying from the side grain surface of wood is only about one-sixth that from the end surface.

Moisture Content

48. The loss in weight expressed as a percentage of the oven-dry weight as above determined shall be considered the moisture content of the specimen.

PERMISSIBLE VARIATIONS

Weights

49. The weight of test specimens and of moisture samples shall be determined within 0.2 per cent.

Measurements

50. Measurements of test specimens shall be made to the nearest 0.01 in.

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[16] See p. 1.

Testing Machine Speeds

51. In no case shall the testing machine speed used vary more than 25 per cent[17] from that specified for a given test. The load shall be applied continuously at the required speed throughout the test.

CALIBRATION

Calibration

52. All apparatus used in obtaining data shall be calibrated at sufficiently frequent intervals to insure accuracy.[18]

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[17] Tests by the U. S. Forest Service show that this speed limitation is necessary in order that the stress shall not vary more than 1 per cent due to variation in rate of fiber strain.

[18] See the Tentative Methods of Verification of Testing Machines (A.S.T.M. Designation: E 4), see p. 895.

(See Appendix, p. 113)

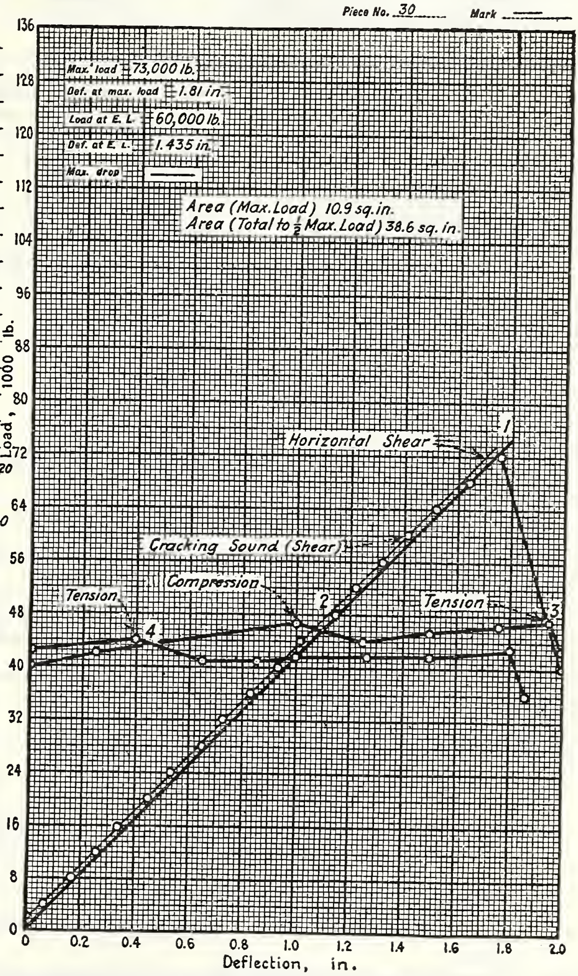
APPENDIX

U. S. DEPARTMENT OF AGRICULTURE
FOREST SERVICE

Project No. 184
Working Plan No. 184
Laboratory No. 123847
Station Madison
Date Nov. 5. 1915
Ship. No. L-308
Stick No. ——
Piece No. 30
Mark ——

Species Longleaf Pine
Kind of test Static Bending
Grade. Extra Select (S1)
Group ——
Loading Third Point
Span 180 in.
Distance between collars ——
Width of plate ——
Machine M-1041
Speed of mach. 0.26 in. per min.
Weight of hammer ——
Height 15.61 in.
Width 7.65 in.
Length 16.00 ft.
Cross-section ——
Weight 515 lb.
Rings per inch 7-7-10-13-17-24-32-29-20
Sap 0
Summerwood 34-34-33-37-30-37-34-32-40
Seasoning Air Dry
Moisture 17.8 % (Average)
Kind of failure Horizontal Shear Followed by Compression and Tension.
Remarks Timber of Medium Density and relatively free from Defects except Small Checks along One Side.
Sketch See Separate Sheet.

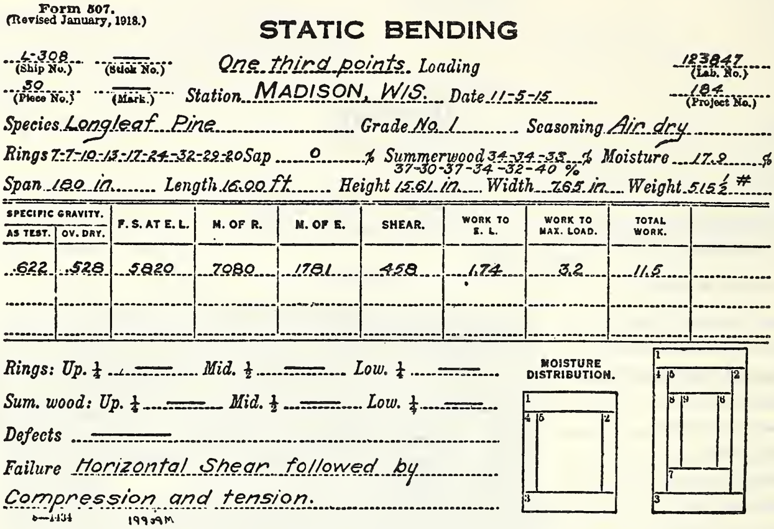
Note : Values for Rings per Inch and Per cent Summerwood are those for each Successive Inch from Edge to Edge of the Timber along an Average Radial Line.



Max. load 73,000 lb.
Def. at max. load 1.81 in.
Load at E. L. 60,000 lb.
Def. at E. L. 1.435 in.
Max. drop ——

Area (Max. Load) 10.9 sq. in.
Area (Total to ½ Max. Load) 38.6 sq. in.

FIG. 1.—Sample Data Sheet for Static Bending Test.



Form 507.
(Revised January, 1918.)

STATIC BENDING

L-308 (Ship No.) — (Stick No.) One third points Loading 123847 (Lab. No.)

30 (Piece No.) — (Mark.) Station MADISON, WIS. Date 11-5-15 184 (Project No.)

Species Longleaf Pine Grade No. 1 Seasoning Air dry

Rings 7-7-10-13-17-24-32-29-20 Sap 0 % Summerwood 34-34-33 % 37-30-37-34-32-40 % Moisture 17.9 %

Span 180 in. Length 16.00 ft. Height 15.61 in. Width 7.65 in. Weight 515½ #

SPECIFIC GRAVITY.		F. S. AT E. L.	M. OF R.	M. OF E.	SHEAR.	WORK TO E. L.	WORK TO MAX. LOAD.	TOTAL WORK.	
AS TEST.	OV. DRY.								
.622	.528	5820	7080	1781	458	1.74	3.2	11.5	

Rings: Up. ¼ — Mid. ½ — Low. ¼ —

Sum. wood: Up. ¼ — Mid. ½ — Low. ¼ —

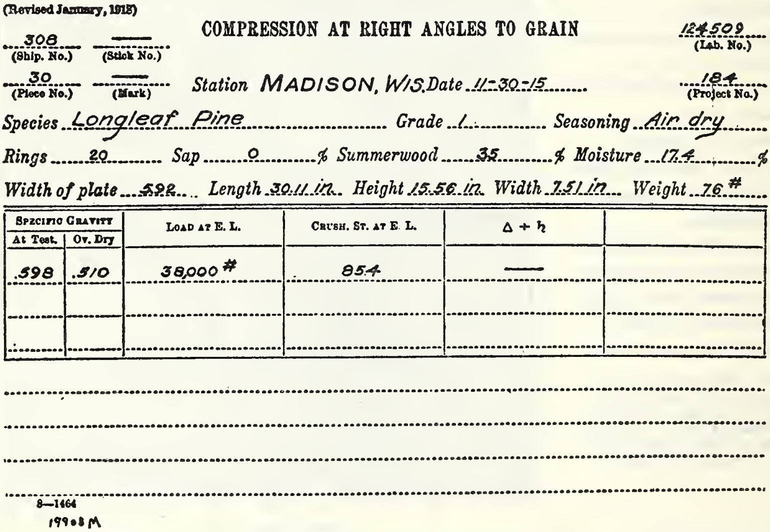
Defects —

Failure Horizontal Shear followed by Compression and tension.

MOISTURE DISTRIBUTION.

8—1434 19959 M

FIG. 2.—Sample Computation Data Card for Static Bending Test.



(Revised January, 1918)

COMPRESSION AT RIGHT ANGLES TO GRAIN

308 (Ship. No.) — (Stick No.) 124509 (Lab. No.)

30 (Piece No.) — (Mark) Station MADISON, WIS. Date 11-30-15 184 (Project No.)

Species Longleaf Pine Grade 1 Seasoning Air dry

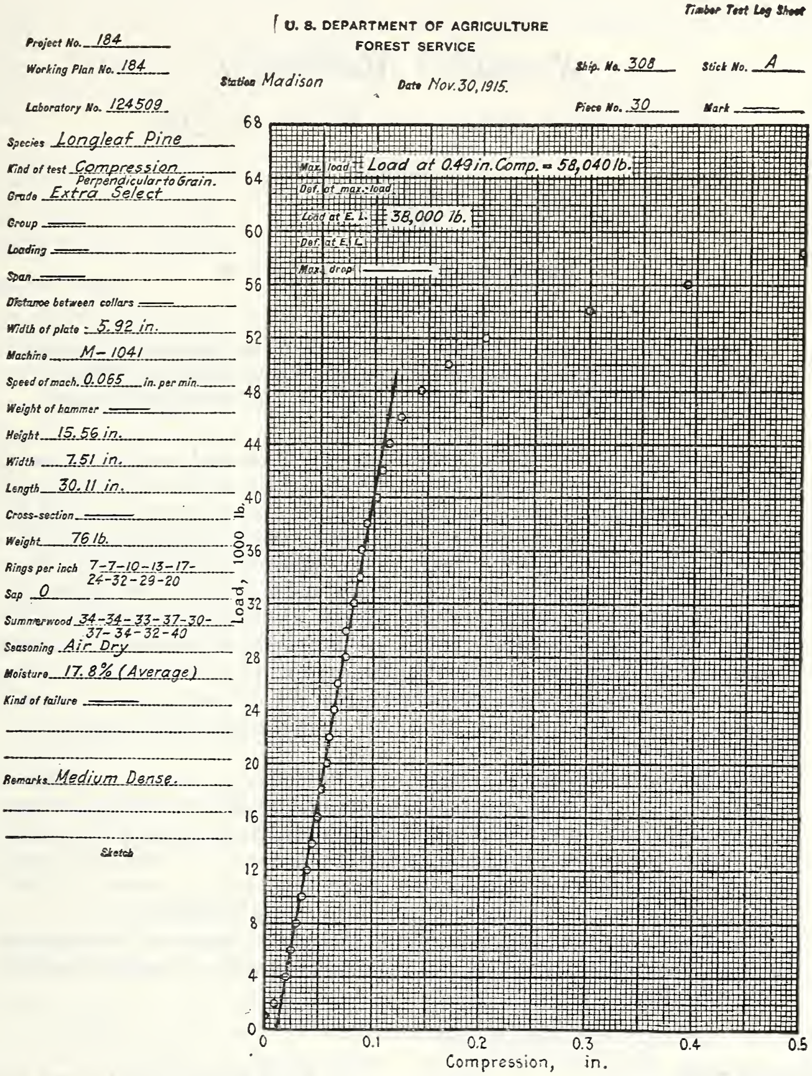
Rings 20 Sap 0 % Summerwood 35 % Moisture 17.4 %

Width of plate .592 Length 30.11 in. Height 15.56 in. Width 7.51 in. Weight 76 #

SPECIFIC GRAVITY		LOAD AT E. L.	CRUSH. ST. AT E. L.	$\Delta + h$	
At Test.	Ov. Dry				
.598	.510	38,000 #	854	—	

8—1464 19908 M

FIG. 3.—Sample Computation Data Card for Compression-Perpendicular-to-Grain Test.



Timber Test Log Sheet

U. S. DEPARTMENT OF AGRICULTURE
FOREST SERVICE

Project No. 184
Working Plan No. 184
Laboratory No. 124509
Station Madison
Date Nov. 30, 1915.
Ship. No. 308
Stick No. A
Piece No. 30
Mark ——

Species Longleaf Pine
Kind of test Compression Perpendicular to Grain.
Grade Extra Select
Group ——
Loading ——
Span ——
Distance between collars ——
Width of plate - 5.92 in.
Machine M-1041
Speed of mach. 0.065 in. per min.
Weight of hammer ——
Height 15.56 in.
Width 7.51 in.
Length 30.11 in.
Cross-section ——
Weight 76 lb.
Rings per inch 7-7-10-13-17-24-32-29-20
Sap 0
Summerwood 34-34-33-37-30-37-34-32-40
Seasoning Air Dry
Moisture 17.8% (Average)
Kind of failure ——
Remarks Medium Dense.
Sketch

Max. load Load at 0.49 in. Comp. = 58,040 lb.
Def. at max. load
Load at E. L. 38,000 lb.
Def. at E. L.
Max. drop ——

FIG. 4.—Sample Data Sheet for Compression-Perpendicular-to-Grain Tests.

Standard Methods of
STATIC TESTS OF WOOD POLES[1]

ASTM Designation: D 1036 - 58

Adopted, 1958.[2]

This Standard of the American Society for Testing Materials is issued under the fixed designation D 1036; the final number indicates the year of original adoption as standard or, in the case of revision, the year of last revision.

One of the important factors involved in the design and economical use of poles for the support of aerial communication and power lines is the value of the maximum fiber stress for the different species of timber used for poles. In order to gain information on this characteristic, mechanical tests on pole size specimens have been made by numerous investigators. These tests have been made in various manners, such as the use of a testing machine, holding the pole butt horizontally in a crib and applying the load at the tip, setting poles in the earth and applying the load at the tip, etc. The amount of seasoning the test poles have received and the type of preservative treatment applied to the poles are additional variables. The result is that it is difficult, if not impossible, to obtain sufficient information pertaining to the various tests to permit accurate comparisons.

It is the purpose of these methods to cover testing procedures in sufficient detail so that the results of tests made in accordance with the methods defined will be comparable. It is, of course, not intended that the making of tests by other methods that may be better adapted to a particular investigation should be discouraged. However, experience gained from tests of several hundred poles has indicated the methods specified are entirely practicable.

The data forms presented have been found to be convenient for recording the test data and for making the calculations necessary for the proper analysis of the test results.

Purpose of Tests

1. Tests of wood poles are made to afford:

(*a*) Data for use in establishing allowable stresses.

(*b*) Data upon which to base economical pole line design.

(*c*) Data on the strength properties of different species in pole sizes.

(*d*) Data as to the influence of defects on the mechanical properties of poles.

(*e*) Data as to the effect of preservatives and preservative treatments on the mechanical properties of poles.

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[1] Under the standardization procedure of the Society, these methods are under the jurisdiction of the ASTM Committee D-7 on Wood.

[2] Prior to adoption as standard, these methods were published as tentative from 1949 to 1958, being revised in 1955.

Note.—It must be recognized that treating procedures to which poles have been subjected may introduce variables which prohibit direct comparisons between different groups of data and complete information on the treating techniques shall form a part of the test records. The procedures specified in these methods, however, apply to tests of either treated or untreated material.

(*f*) Data upon which to base a correlation between the strength properties of full-size poles and those of small clear specimens of the same species.

Classes of Tests

2. In general, tests of poles are divided into major and minor tests as follows:

(*a*) *Major tests* are static bending tests made on the principal members under investigation together with age, rate of growth, moisture, and density determinations.

(*b*) *Minor tests* are those tests made on small clear specimens cut from the principal members, including static bending, compression parallel to grain, toughness, compression perpendicular to grain, hardness, moisture content, and density.

COLLECTION OF MATERIAL

Identification

3. The material for test shall be selected by one qualified to identify the species.

Number of Major Specimens

4. For each species under investigation it is desirable that a minimum of 50 specimens be selected for test. The poles shall be carefully chosen as representative of the commercial product being supplied.

Note.—Tests may be conducted to study the effect of some particular characteristic and in such cases the selection of test specimens shall be made in such a manner as to insure that the range of the characteristic under study has been adequately sampled.

Field Notes

5. Field notes fully describing the material, when the information is available, shall be carefully made by the collector. These notes shall, so far as possible, supply data outlined as follows and shall be incorporated into the test records:

FIELD NOTES

Project No.................................
Locality Cut...............................
County.....................................
Slope . . . Elevation......................
Undergrowth................................
Crown......................................
Soil.......................................
Shipment No................................
Species....................................
Date Cut...................................
Seedling or Sprout.........................
How and when transported from woods.......

Field Marking

6. Each specimen shall be legibly marked on the butt with its length, class, and source of supply, in accordance with the requirements of Section 4.5 of the American Standard Specifications and Dimensions for Wood Poles (ASA No.: 05.1) using such symbols as may apply to each specimen.

CONDITIONING AND MEASURING OF SPECIMENS FOR TESTING

Conditioning

7. Two basic procedures for conditioning and moisture content are provided as follows:

(*a*) *Method A*, providing for air seasoning and butt soaking of poles prior to test.

(*b*) *Method B*, providing for tests of poles in the full-length green condition.

Note.—Method A, providing for butt soaking of poles after seasoning, has been used as a preconditioning method when it is desired to provide tests simulating, as nearly as possible, actual field use under certain climatic conditions.

Method B, providing for tests of poles in the green condition, has been used where the stability of moisture - strength relationships thus established is particularly desired for comparison between species, grades, and testing procedures, and for establishing relationship of strength between full-size poles and that of small clear specimens taken from the pole material.

Alternative Conditioning Requirements

8. (*a*) *Method A.*—All poles to be tested shall be air-seasoned, but when tested shall have their butt section (from the ground line to the butt) at a moisture content equal to or above the fiber saturation point. Butt soaking shall be conducted in a manner to prevent decay and with the poles in a vertical position. Moisture determinations of the butt section shall be made by means of increment borings. The determinations shall be made by using the portions of the borings nearest the pole surface with a length of boring equal to one-half the pole radius. Increment borings shall be taken at least 12 in. below the ground line. All poles during air seasoning shall be stored on skids at least 2 ft above the ground.

NOTE.—For the purposes of these methods, poles will be considered air-seasoned when two successive determinations made one week apart indicate the moisture content of the pole to have reached a practically constant value at or below 22 per cent.

(*b*) *Method B.*—All poles to be tested shall be selected in the green condition and shall be tested before any seasoning has taken place. If there is any delay in testing which would cause seasoning, this shall be prevented by proper storage, preferably by full-length immersion in water. If other methods of maintaining the green condition are employed, care shall be exercised to prevent the development of stain or decay. Special moisture determinations of the test sections are not required prior to test (Section 23).

Initial Measurements

9. Before placing a pole in the testing apparatus, a record shall be made of the following items:

(*1*) The weight,

(*2*) The length to the nearest inch,

(*3*) The class,

(*4*) The circumference at butt, at tip, and at the ground line to the nearest $\frac{1}{16}$ in.,

(*5*) The diameter of each knot over $\frac{1}{2}$ in. in diameter and its location on the surface of the pole relative to the butt and to the longitudinal center line of the face of the pole, and

(*6*) Any possible strength reducing defects observed other than knots, such as sweep, crook, checks, shakes, spiral grain, insect damage, etc.

STATIC BENDING TESTS OF POLES

Cantilever Method

Apparatus

10. (*a*) A schematic drawing of the testing apparatus and field layout for conducting the tests is shown in Fig. 1.

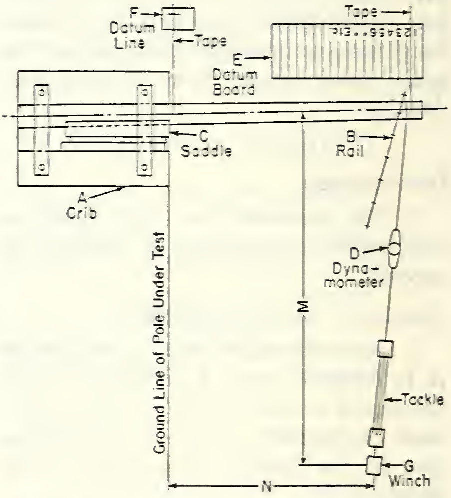
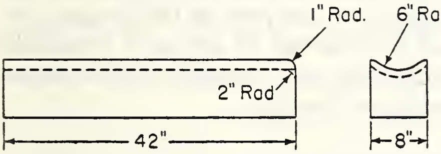


FIG. 1.—Schematic Layout of Field Mechanical Tests of Wooden Poles.

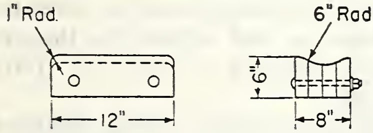
For convenience of reference, the principal features of the layout are denoted on the drawing by capital letters. The pole to be tested shall be held securely from the butt to the ground line in the crib *A*. The crib shall be built in such a manner that there will be no significant movement of the pole butt during the test. The design of the crib and holding devices shall be such that all vertical and rotational motion of the pole shall be prevented.

(*b*) A support *B* shall be provided at a point about three-quarters of the distance from the ground line to the point of load application to minimize vertical movement at that point and reduce the stress from the weight of the pole. This support shall be such that any friction associated with the deflection of the pole under load shall not be a significant portion of the measured load on the pole.

(*c*) As a pole is placed in the testing apparatus, it shall be rotated until its gained side, or face, is up. The pole shall be shifted longitudinally until its ground line coincides with the front face of the crib, and then it shall be secured firmly in place (see Paragraph (*a*)). A wooden saddle *C*, Fig. 1, with a concave surface on the pole side and rounded edges, shall be placed against the pole to prevent injury to the ground-line section. This saddle shall be made of wood at least as soft as the pole under test and shall have dimensions as shown in Fig. 2.



(*a*) Wooden Saddle, Solid or Laminated as Shown for Cradle.



(*b*) Wooden Cradle, Laminated, Glued, and Bolted.

Fig. 2.—Saddle and Cradle.

Load

11. The load shall be applied at a point 2 ft from the tip of the pole by a power winch, or other means of sufficient capacity and capable of pulling at a constant rate of speed. The pulling line shall be kept level between the winch position and the point where load is applied to the pole. The load shall be applied continuously until the pole fails, and at such a rate of speed as to cause a deflection at the point of load of N inches per minute, as determined by the formula:

$$N = \frac{2\pi Z L^2}{3C_g}$$

where:

N = rate of deflection in inches per minute,
Z = rate of fiber strain in inches per inch per minute = 0.0007, the value specified in the Methods of Static Tests of Timbers in Structural Sizes (ASTM Designation: D 198),[3]
L = lever arm in inches, and
C_g = circumference at ground line in inches.

Pulling Line

12. The pulling line shall be secured around the pole at the load point. The load measuring device shall be placed in series with the pulling line and the line to the winch with a free running swivel on each side of it.

Winch Positions

13. If the winch *G*, Fig. 1, is set far enough away from the pole to make the angle between the initial and final positions of the pulling line small, the error in assuming that the pull is always perpendicular to the original direction of the pole axis will be negligible. The winch

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[3] Appears in this publication, see Contents in Numeric Sequence of ASTM Designations at front of book.

shall be located at the positions given in Table I.

TABLE I.—WINCH POSITIONS.

Pole Length, ft.	Distance M from Pole Axis, ft.[a]	Distance N from Ground Line, ft.[a]
20........	100	13.5
22........	110	15.5
25........	125	17.5
30........	150	22.0
35........	175	26.5
40........	200	31.0
45........	225	35.5
50........	250	40.0
55........	275	44.5
60........	300	49.0

[a] See Fig. 1 for location of distances M and N.

Load Measurement

14. Load shall be measured by a suitable measuring device placed in series in the pulling line. The recommended method is a calibrated metal tension bar fitted with calibrated electric-type strain gages, suitably wrapped or housed for protection against shock when the pole breaks. This method permits remote reading of loads and minimizes the possibility of personal injury during test. Alternatively, where electric-type strain gaging equipment is not available, load may be measured by a dynamometer of suitable capacity, graduated in 50-lb divisions. Calibration of the dynamometer shall be checked at frequent intervals during the tests. The load-measuring device shall be supported on a sled or cradle moving on a suitable platform or level space. The sled or cradle and the surface on which it moves shall be such that the force required to pull it shall not add materially to the measured load on the pole.

Deflections

15. (*a*) The deflection of the pole at the point of load shall be measured at such intervals of load as to provide not less than 15 simultaneous readings of load and deflection. A greater number of readings (25 to 40) is preferred. The measurement of the deflection of the load point shall be made in a direction perpendicular to the unloaded position of the pole axis. A measurement of the movement of the load point toward the butt resulting from the deflection shall also be made at each increment of load.

NOTE.—These measurements may be facilitated if a piece of plywood (datum board), *E*, Fig. 1, is ruled with lines perpendicular to the unloaded axis of the pole and spaced 1 in. apart. The edge of the plywood board away from the pole may be used as the datum line from which the deflection is measured. Then as the pole is deflected under load, the tape by which the deflection is measured is kept parallel to the ruled lines and its motion toward the butt may be measured by noting the line the tape is parallel to when the deflection is measured.

(*b*) A second datum line shall be established at *F*, Fig. 1, from which movement of the ground line shall be measured.

(*c*) Alternatively, the deflection of the pole may be measured with respect to a wire tightly stretched along the upper surface of the pole between the load point and a point 1 ft from the butt. The movement of the wire relative to the position of the pole at the ground line can be observed by means of a suitable horizontal scale attached to the upper surface of the pole.

Procedure

16. (*a*) Before any load is applied to the pole, zero readings shall be taken for the following and entered in the appropriate columns of Table II (Data Sheet 1):

(*1*) On the tape which measures the deflection of the load point to the edge of the datum board, *t*

(*2*) On the datum board the line to which the tape of Item (*1*) is parallel, *s*,

TABLE II.—SAMPLE DATA SHEET 1.

Pole Strength Tests

Test Pole No: 26

Species: So. Pine

Class and Length: 6-30

Weight, lb.:

Plant and Treatment: Spartanburg - Salt

CIRCUMFERENCES (Inches)

GL.* 26.9

Load Point: 19.1

Tip: 18.5

LENGTHS (Feet-Inches)

Butt to GL.* 5'-5 3/4"

GL* to Load Point: 22'-6"

Load Point to Break: 16'-6½"

Observed Dynamometer Reading, lb.	t*		s*, in.	g*, in.	Remarks
	Feet	Inches			
0	10	8 3/4	5	0	
200	11	1/2	5 5/8	0	
400	11	3 7/8	6 1/4	1/16-	
600	11	9 1/4	6 1/4	1/16+	
800	12	1	6 3/8	1/8	
1000	12	6	6 5/8	3/16	Start time
1200	12	10 3/8	6 3/4	3/16	
1400	13	4 1/8	7 1/8	1/4	
1600	13	11 1/2	7 3/8	5/16	3 m 4 s
1800	14	8 7/8	7 1/2	3/8	
2000	(14.95 =	Est.	(s =	Est.)	1840 Max.
2200			10.0		Short break at knot whorl
2400			(9.8 min.)		
2600					
2800					
3000					
3200					
3400					
3600					
3800					
4000					Total s = 5

*GL (Ground Line) = Point of support.
t = Perpendicular distance from tip datum to load point.
s = Distance load point moves toward butt.
g = Distance pole moves at ground line.

Initials of Recorder: R.C.L.
Date: 9-5-39

TABLE III.—SAMPLE DATA SHEET 2.

Pole Strength Tests

Test Pole No. 26

Dynamometer		Corrected** Deflection, in.	Section	Circumference, in.
Observed Reading, lb.	Corrected* Reading, lb.			
0			Butt	27.1
200	190		2'	27.0
400	350		4'	26.8
600	550		6'	27.1
800	780		8'	25.5
1000	980		10'	24.9
1200	1170		12'	24.5
1400	1370		14'	23.7
1600	1560		16'	23.1
1800	1790		18'	22.8
2000			20'	21.8
2200			22'	21.4
2400			24'	20.8
2600			26'	20.1
2800			28'	19.3
3000			30'	18.7
3200			GL	26.9
3400			11'5¼" Break	24.6
3600				
3800				
4000				

$$F = \frac{KLP}{C^3} \quad \text{and} \quad F_b = \frac{KL'P}{C_1^3}$$

where:

$K = 32\pi^2 = 315.82734$,

L and L' = Lever arms in inches,

P = maximum load in pounds, and

C and C_1 = circumferences at ground line and at break, respectively, in inches.

Distance	Inches
Load Point to GL.***	270
Total s***	5
L =	265
Load Point to Break	199
Total s***	5
L' =	194

P = 1835 lb.

C^3 = 19465.109

C_1^3 = 14886.936

(MR): 7890 psi.

Maximum fiber stress at break section (MB): 7550 psi.

* Corrections based on calibration curves.

**Corrected deflection = Difference between the t values of Table II (Data Sheet 1) for any load and zero load, minus a correction for movement at point of support.

*** See Table II (Data Sheet 1)

Initials of Recorder: R. C. E.

Date: 4-16-40

(*3*) On the tape for measuring ground line movement, g, and

(*4*) On the horizontal scale at the ground line of the pole when the wire is used.

(*b*) At this time also the following measurements shall be made and recorded in the appropriate place in Table II (Data Sheet 1):

(*1*) Actual distance from butt of test pole to ground line (that is, point of support),

(*2*) The distance from ground line to point of load,

(*3*) Circumference at ground line and at point of load,

(*4*) Species of timber,

(*5*) Source of pole,

(*6*) Preservative treatment if any, and

(*7*) Test number.

(*c*) The circumference measurements shall be made to the nearest 0.1 in.

(*d*) The difference between the zero and any subsequent t readings measures the movement of the point of load in direction perpendicular to the unloaded position of the pole axis. Similarly, the difference between the zero and subsequent s readings measures the movement of the point of load toward the pole butt in a direction parallel to the unloaded position of the pole axis. The data relative to the ground line movement, g readings, will be needed only for correction of the deflection readings and for a calculation of the modulus of elasticity if this characteristic is desired.

(*e*) The load shall be applied continuously and at a uniform rate until the pole fails. At each increment in the load, as indicated by the load measuring device, simultaneous readings of t, s, and g shall be made and recorded in Table II (Data Sheet 1) until failure occurs in the pole. The maximum load shown by the load measuring device shall be recorded. After failure an estimate shall be made of the break location and the distance from this location to the point of load shall be measured and recorded.

Test Results

17. (*a*) *Load Correction.*—The corrected load reading shall be recorded in the appropriate column of Table III (Data Sheet 2). These corrected readings shall be determined from calibration curves of the load measuring device.

(*b*) *Lever Arm Correction.*—The difference between the t and s readings and the zero readings made during each test are, respectively, measures of the movement of the point of load in a direction perpendicular to and parallel to the unloaded position of the pole axis. The difference between the zero and final s readings shall be deducted from the distance from point of load to ground line and from the distance from point of load to point of break, to obtain the true lever arm for the calculation of the fiber stress at the ground line and at the breaking point, respectively.

(*c*) *Load Deflection Curve.*—A load deflection curve shall be plotted for each pole tested.

(*d*) *Calculations.*—The maximum fiber stress at the ground line shall be calculated by the following formula:

$$F = \frac{32\pi^2 Pa}{C^3}$$

where:

F = maximum fiber stress at ground line in pounds per square inch,
P = load at failure (corrected) in pounds,
a = distance from ground line to point of load in inches, and
C = circumference at ground line in inches.

If the maximum fiber stress at break is desired, it shall be calculated by the following formula:

$$F_b = \frac{32\pi^2 Pa'}{C_a^3}$$

where:

F_b = maximum fiber stress in pounds per square inch,
P = load at failure (corrected) in pounds,
a' = distance from break to point of load in inches, and
C_a = circumference at point of break in inches.

The modulus of elasticity may be calculated by the following formula:

$$E = \frac{4a^3b}{3\pi L}\left(\frac{P}{\Delta A^3 B}\right)$$

where:

E = modulus of elasticity in pounds per square inch,
a = length from ground line to tip support of wire, in inches,
b = length from ground line to butt support of wire, in inches,
L = length between two points of support of wire ($a + b = L$), in inches,
P = applied load at tip end, in pounds,
Δ = observed deflection from wire at ground line, in inches,
A = radius of pole at ground line, in inches, and
B = radius of pole at point where load is applied, in inches.

NOTE 1.—If a crib consisting of vertical poles is used, the modulus of elasticity shall be calculated from the wire deflection at ground line, using the formula of Section 21(*c*).

NOTE 2.—Since shear deformation makes a negligible contribution to the deflection of the pole in test, the modulus of elasticity calculated by the formula will correspond more nearly to the true (compression) modulus of elasticity of the wood than to the apparent (bending) modulus in the standard test of a small clear specimen.

Machine Method

Apparatus

18. (*a*) The poles shall be tested in a hydraulic or mechanical testing machine with the load applied by the movable head of the testing machine at the ground line of the pole.

(*b*) When the poles are short enough to permit supporting the tip end on an extension of the weighing platform, the load may be observed by means of the weighing system of the machine. The extension wing of the testing machine shall be secured in such a manner that it will be capable of carrying the loads applied to it. An arrangement of such a testing apparatus is shown schematically in Fig. 3(*a*). Alternatively, and for longer poles, one or both ends of the pole may be supported independently of the testing machine with provision for observing the load by means of a properly calibrated weighing device, such as a hydraulic weighing cell, at either or both ends or at the load point. Such an arrangement is shown in Fig. 3(*b*).

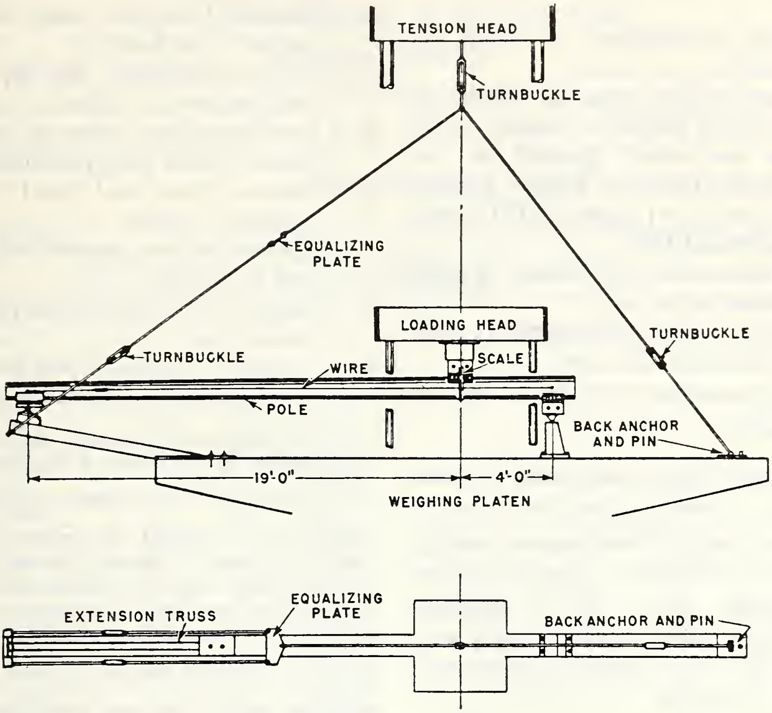
(*c*) The pole shall rest at each end in cradles (Fig. 2) supported in rocker bearings free to rotate about a horizontal axis as the pole deflects. The cradle and rocker bearing at each end shall rest on rollers to accommodate longitudinal movement of the pole during test. The wood used for the cradles shall be no harder than that of the poles being tested.

(*d*) The axis of rotation of the rocker bearings shall be 1 ft from the butt and 2 ft from the tip end of the pole, respectively. The poles shall be placed in the cradles with the gained side up.

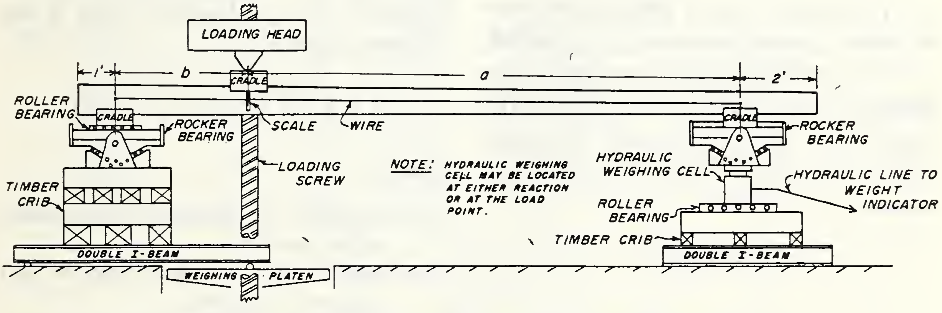
Deflection

19. Deflection of the pole under test shall be measured at the ground line.

NOTE.—The deflection may be measured by stringing a fine wire taut between nails driven into the neutral axis of the pole directly over the end supports, and crossing a scale secured to the pole at the ground line.



(*a*) With extension wing of testing machine.



(*b*) With pole support independent of testing machine.

Fig. 3.—Schematic Diagram of Set-up for Testing Wooden Poles in Transverse Bending.

Procedure

20. (*a*) The load shall be applied continuously until the pole fails and at such a rate of speed as to cause a deflection at the point of load of N inches per minute, as determined by the formula:

$$N = \frac{2\pi abZ}{3C_l}$$

where:

N = rate of deflection in inches per minute,
Z = rate of fiber strain in inches per inch per minute = 0.0007, which is the value specified in the Methods of Static Tests of Timbers in Structural Sizes (ASTM Designation: D 198),[3]
a = distance from tip bearing to point of load in inches,
b = distance from butt bearing to point of load in inches, and
C_l = circumference at point of load in inches.

(*b*) Deflection readings shall be taken at such increments of load as to provide not less than 15 simultaneous readings of load and deflection. A greater number of readings (25 to 40) is preferred.

(*c*) Each failure shall be noted as it occurs and its location marked on a sketch of the pole.

Report and Calculations

21. (*a*) Figs. 4 and 5 indicate one form in which the test data may be recorded.

(*b*) *Calculations.*—If the weight of the section of pole from the load point to the tip end has been determined, the maximum fiber stress at ground line may be calculated as follows:

$$T = \frac{Pb}{L}$$

$$F = \frac{\left(T + t - \frac{w}{2}\right)a}{0.0982d^3}$$

where:

T = tip reaction at maximum load due to superimposed load in pounds,
P = maximum superimposed load on pole in pounds,
b = distance from load point to butt support in inches,
L = distance between the tip and butt supports in inches,
F = maximum fiber stress at ground line in pounds per square linch,
a = distance from load point to tip support in inches,
t = tip reaction due to dead weight of pole in pounds,
d = diameter of pole at load point in inches, and
w = weight of section of pole from the load point to the tip end in pounds.

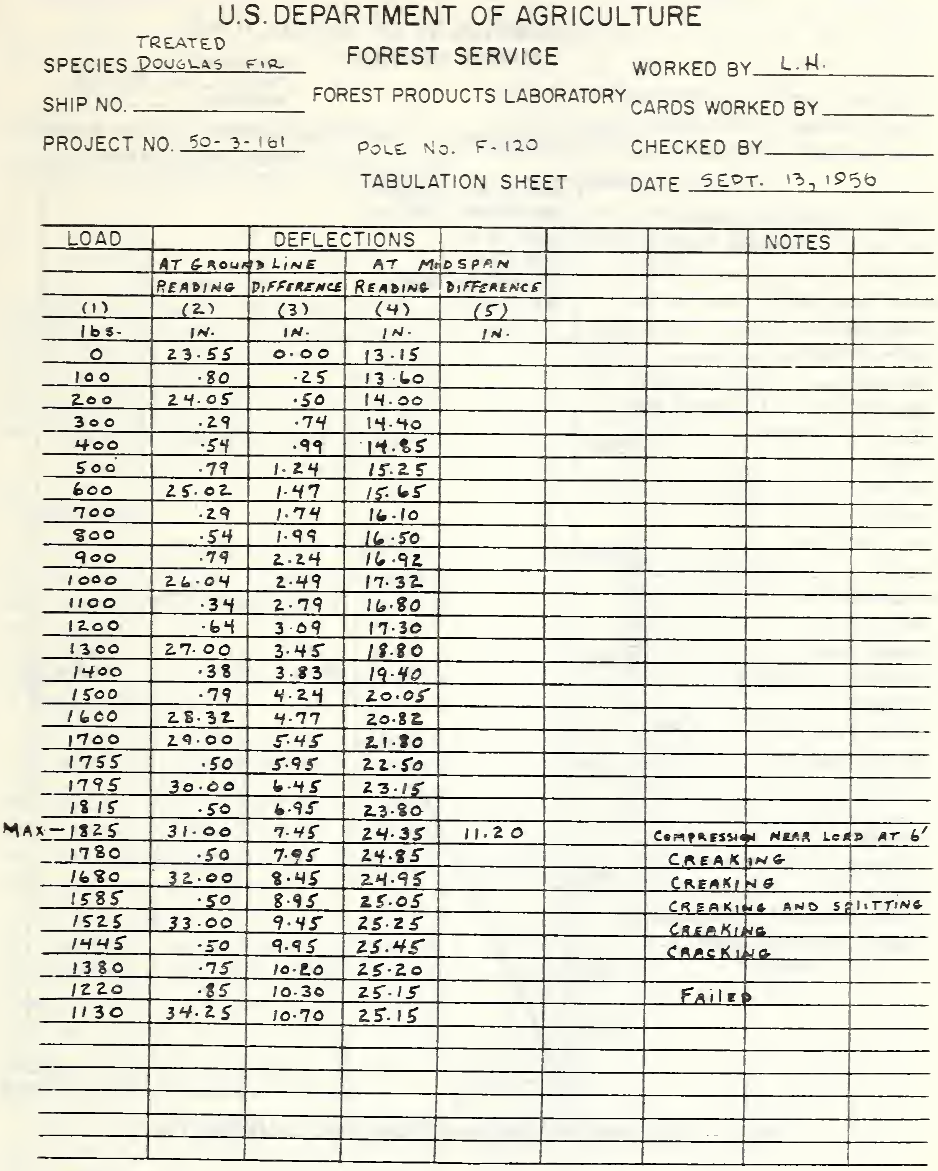
NOTE.—The formula assumes that the center of gravity of the section of the pole above the ground line acts at a distance of $\frac{a}{2}$ from the load point. If so desired, the center of gravity can be determined by balancing the section on a narrow fulcrum and the formula altered accordingly for each pole. Experience has indicated that the error involved in using the distance $\frac{a}{2}$ when calculating bending stress is usually negligible, except in long and large poles.

(*c*) The modulus of elasticity of the pole shall be calculated from the deflections at the load point by use of the following formula:

$$E = \left(\frac{4a^3b}{3\pi}\right)\left(\frac{T}{\Delta A^2B(AL - Bb)}\right)$$

where:

E = modulus of elasticity in pounds per square inch,
a = length from ground line to tip support, in inches,
b = length from ground line to butt support, in inches,
L = length between two points of support ($L = a + b$ = test span of the pole), in inches,
T = tip reaction from superimposed load, in pounds,
Δ = observed deflection from wire at ground line, in inches,



U.S. DEPARTMENT OF AGRICULTURE

FOREST SERVICE

FOREST PRODUCTS LABORATORY

SPECIES TREATED DOUGLAS FIR

SHIP NO. ______

PROJECT NO. 50-3-161

POLE NO. F-120

TABULATION SHEET

WORKED BY L. H.

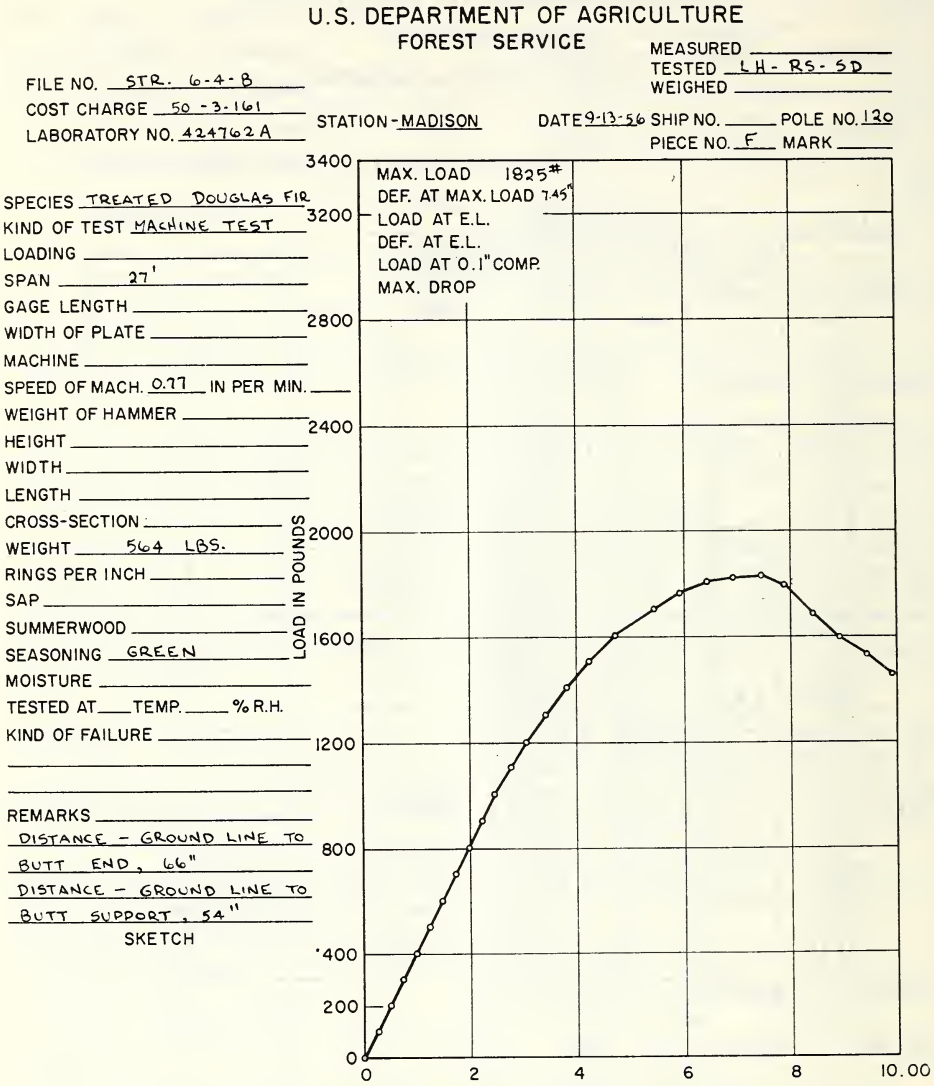
CARDS WORKED BY ______

CHECKED BY ______

DATE SEPT. 13, 1956

LOAD	DEFLECTIONS						NOTES	
	AT GROUND LINE		AT MIDSPAN					
	READING	DIFFERENCE	READING	DIFFERENCE				
(1)	(2)	(3)	(4)	(5)				
lbs.	IN.	IN.	IN.	IN.				
0	23.55	0.00	13.15					
100	.80	.25	13.60					
200	24.05	.50	14.00					
300	.29	.74	14.40					
400	.54	.99	14.85					
500	.79	1.24	15.25					
600	25.02	1.47	15.65					
700	.29	1.74	16.10					
800	.54	1.99	16.50					
900	.79	2.24	16.92					
1000	26.04	2.49	17.32					
1100	.34	2.79	16.80					
1200	.64	3.09	17.30					
1300	27.00	3.45	18.80					
1400	.38	3.83	19.40					
1500	.79	4.24	20.05					
1600	28.32	4.77	20.82					
1700	29.00	5.45	21.80					
1755	.50	5.95	22.50					
1795	30.00	6.45	23.15					
1815	.50	6.95	23.80					
MAX—1825	31.00	7.45	24.35	11.20			COMPRESSION NEAR LOAD AT 6′	
1780	.50	7.95	24.85				CREAKING	
1680	32.00	8.45	24.95				CREAKING	
1585	.50	8.95	25.05				CREAKING AND SPLITTING	
1525	33.00	9.45	25.25				CREAKING	
1445	.50	9.95	25.45				CRACKING	
1380	.75	10.20	25.20					
1220	.85	10.30	25.15				FAILED	
1130	34.25	10.70	25.15					

FIG. 4.—Tabulation of Data Observed in Machine Test.



U.S. DEPARTMENT OF AGRICULTURE
FOREST SERVICE

MEASURED
TESTED LH - RS - SD
WEIGHED

FILE NO. STR. 6-4-B
COST CHARGE 50 -3-161
LABORATORY NO. 424762 A

STATION - MADISON
DATE 9-13-56
SHIP NO.
POLE NO. 120
PIECE NO. F
MARK

SPECIES TREATED DOUGLAS FIR
KIND OF TEST MACHINE TEST
LOADING
SPAN 27'
GAGE LENGTH
WIDTH OF PLATE
MACHINE
SPEED OF MACH. 0.77 IN PER MIN.
WEIGHT OF HAMMER
HEIGHT
WIDTH
LENGTH
CROSS-SECTION
WEIGHT 564 LBS.
RINGS PER INCH
SAP
SUMMERWOOD
SEASONING GREEN
MOISTURE
TESTED AT ___ TEMP. ___ % R.H.
KIND OF FAILURE

REMARKS
DISTANCE – GROUND LINE TO BUTT END, 66"
DISTANCE – GROUND LINE TO BUTT SUPPORT, 54"

SKETCH

MAX. LOAD 1825#
DEF. AT MAX. LOAD 7.45"
LOAD AT E.L.
DEF. AT E.L.
LOAD AT 0.1" COMP.
MAX. DROP

FIG. 5.—Load-Deflection Curve and Related Data in Machine Test.

A = radius of pole at ground line, in inches, and
B = radius of pole at tip support, in inches.

Where a superimposed load P is measured at the ground line, the tip reaction T can be calculated from the formula

$$T = P\left(\frac{b}{L}\right)$$

NOTE.—Since shear deformation makes a negligible contribution to the deflection of the pole in test, the modulus of elasticity calculated by the formula will correspond more nearly to the true (compression) modulus of elasticity of the wood than to the apparent (bending) modulus in the standard test of a small clear specimen.

PROCEDURE AFTER TESTING

Photographs

22. A photograph shall be taken or a sketch shall be made of each pole failure as a portion of the permanent record of the tests.

Age, Rate of Growth, and Moisture Determination

23. (*a*) Two disks, each 1 in. in thickness, shall be cut from the pole approximately 1 ft from the ground line toward the butt. The age, sapwood thickness, and number of rings per inch shall be determined from one disk.

(*b*) The other disk shall be reserved for moisture and specific gravity determinations. The disk shall be split along radii into six approximately equal sectors. If any of the sectors contain knots, these shall be split off and all knotty portions shall be discarded.

(*c*) Three alternate (nonadjacent) knot-free sectors shall be selected for the determination of the moisture content, and if desired, the retention of preservative. The other three sectors shall be retained for the determination of specific gravity (see Paragraph (*d*)). The sapwood shall be split off each of the moisture sectors. All splinters and sawdust shall be removed from the pieces and the weight of the sapwood and the heartwood pieces shall be obtained immediately. The specimens of sapwood and heartwood shall then be stored in suitably labeled containers until tests for moisture content (and preservative retention) can be made. Moisture determinations of untreated specimens and tests for the moisture content and preservative retention of treated specimens shall be made by standard methods.

(*d*) The volume of the specific gravity sectors shall be determined by displacement as soon as possible after the sectors are cut. The sectors shall then be oven dried and the specific gravity determined by the formula:

$$\text{Specific gravity} = \frac{\text{oven dry weight in grams}}{\text{volume in cu cm}}$$

Specimens for Minor Tests

24. (*a*) Minor specimens shall be cut from the end of the butt section nearest the disks mentioned in Section 23 or from a section cut from the butt of the pole prior to the major test. The number and types of specimens to be taken for minor tests shall be determined in accordance with the overall objectives of the test program (Section 2(*b*)). As a minimum, however, five 2 by 2 by 40-in. test samples shall be taken to furnish five static bending and five compression-parallel-to-grain specimens. When poles are of such small size as to preclude the use of test specimens 2 by 2 in. in cross-section, specimens 1 by 1 in. in cross-section may be used in accordance with the Methods of Testing Small Clear Specimens of Timber (ASTM Designation: D 143).[3] All specimens shall be clear and free of defects. When the minimum number of specimens mentioned above is taken, they shall be from as near the surface of the butt as possible without having surface defects or imperfections appear in the specimens. Each specimen shall be marked to show its position relative to the compression side of the pole and shall also bear the

number of the pole from which it was taken as well as its own number.

NOTE.—If 40-in. specimens cannot be obtained from the butt section, 30-in. specimens shall be obtained and five additional specimens each 2 by 2 by 10 in. shall be taken for tests of compression parallel to grain.

(*b*) All minor test specimens shall be handled in such a manner as to keep the moisture content above fiber saturation until tested.

Procedure for Minor Tests

25. The procedure for conducting the minor tests, including a determination of moisture content and specific gravity, shall conform to that prescribed in the Methods of Testing Small Clear Specimens of Timber (ASTM Designation: D 143).[3]

TABULATION OF RESULTS

Tabulation of Results

26. A table shall be prepared, listing the following information for each pole:

(*1*) Pole number,

(*2*) Average moisture content of butt section of pole,

(*3*) Moisture content of heartwood at ground line,

(*4*) Moisture content of sapwood at ground line,

(*5*) Specific gravity of pole, volume as tested, weight oven-dry,

(*6*) Rate of growth (rings per inch),

(*7*) Age of tree, years,

(*8*) Sapwood, per cent of total cross-section,

(*9*) Sapwood, depth in inches,

(*10*) Weight of pole, pounds,

(*11*) Temperature of pole at time of test,

(*12*) Circumference of pole at ground line, inches,

(*13*) Circumference of pole at break, inches,

(*14*) Circumference of pole at butt, inches,

(*15*) Circumference of pole at tip, inches,

(*16*) Maximum load, pounds,

(*17*) Maximum fiber stress at ground line, pounds per square inch,

(*18*) Maximum fiber stress at break, pounds of square inch, if calculated, and

(*19*) Modulus of elasticity, if calculated, in pounds per square inch.

(See Appendix, p. 131).

APPENDIX

Since these methods cover, in general, the kinds of data to be collected in a series of tests, and specific directions as to how these data should be taken are not given, it is thought the following information on apparatus design and descriptions of how certain data were obtained in successful tests might be helpful.

Figure 6 shows a field layout which has been used, with crib *A*, test pole, supporting rail *E*, pulling tackle *G*, and winch *H*. The sketch indicates winch positions for three lengths of poles. Details of parts of the testing apparatus are also included. Points *B* and *C* are reference points for measuring the movement of the ground line and the load point of the test pole, respectively. The sand and plank barrier at *D* is a safety device to protect against failure of the tackle or pulling line. The screens *F* are to protect the man reading the dynamometer from possible breaks in the pulling line.

Figure 7 shows details of a concrete testing crib and crib fittings that have proven adequate for conducting pole tests. Fig. 8 shows a testing crib made of timber and the necessary bracing.

A convenient and satisfactory method of making the readings of the various data required is to have the person reading the load on the dynamometer blow a whistle for each 200-lb increment of load. The person reading the deflection then reads the tape for deflection and the location of the tape, and the tape for the movement of the pole at the ground line is then read. If one person is designated as the recorder, he may make his record easily if a sequence is established for the readings to be shouted out after each whistle.

The following is a method for recording knots and defects that has also proved convenient:

(*1*) The pole to be measured is laid out on skids.

(*2*) Before measuring, the pole is rolled so that its face (that is, its gain side) is up.

(*3*) The zero end of a steel tape is secured to the butt surface of the pole in such a manner that the zero mark coincides with the uppermost point of the butt surface.

(*4*) The tape is then stretched taut along the longitudinal center line of the face of the pole and secured to the top surface of the pole.

(*5*) At the midpoint, the tape is secured to the pole to prevent sag when the pole is subsequently rolled for knot measurement.

(*6*) At intervals of 2 ft, beginning at the extreme butt, circumferences are measured and recorded. The pole is then rolled through an angle of 90 deg and secured.

(*7*) Using the tape as a reference line, the diameter of each knot more than ½ in. in diameter, its distance from butt, and its distance circumferentially from the tape are measured and recorded.

(*8*) A record is made of any strength reducing defects other than knots that may be present. Fig. 9 shows a form that will assist in making the above records.

The "Working Plan for Grading Hardwood Logs" dated January 1, 1947, and issued by the Forest Products Laboratory at Madison, Wisconsin, contains directions for noting defects, etc., on a form for logs. These directions and form could be easily adapted for use in pole tests.

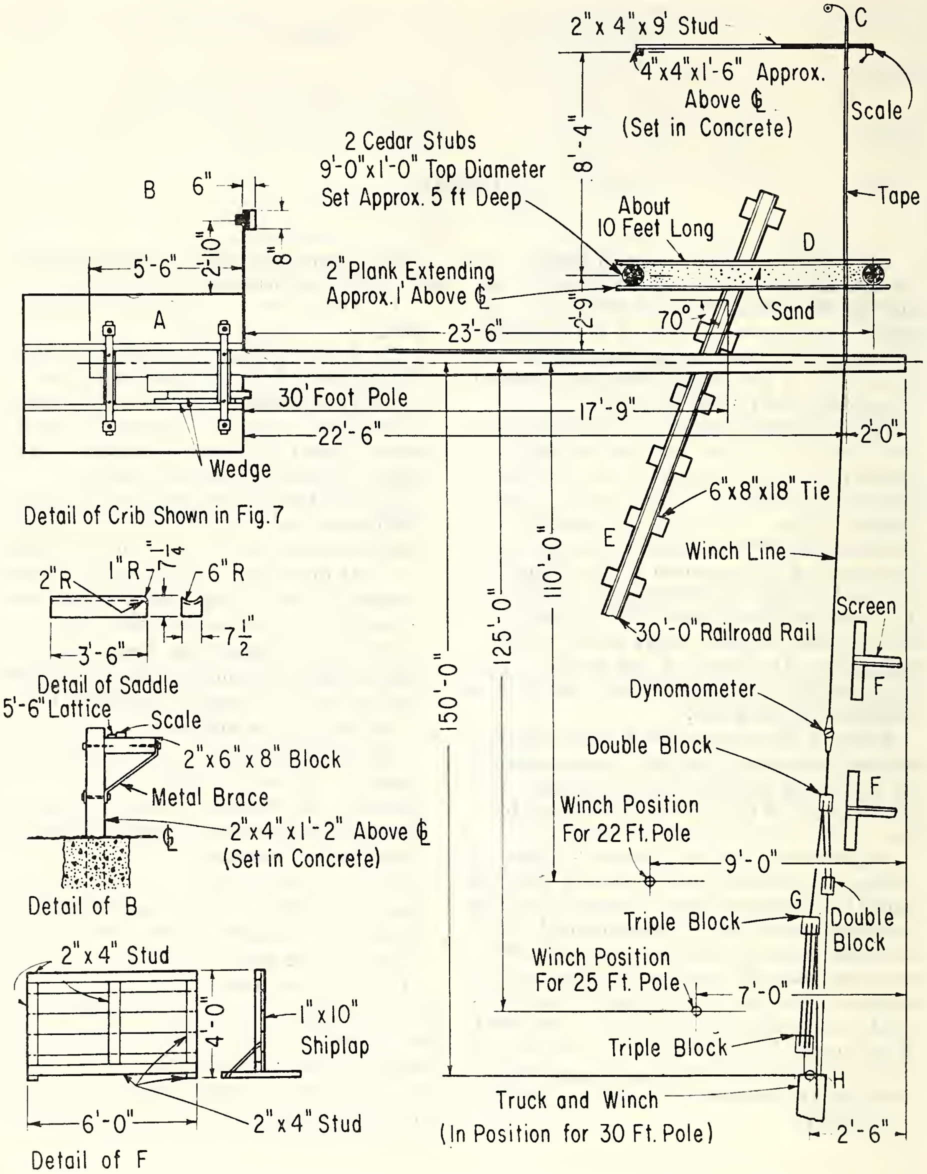
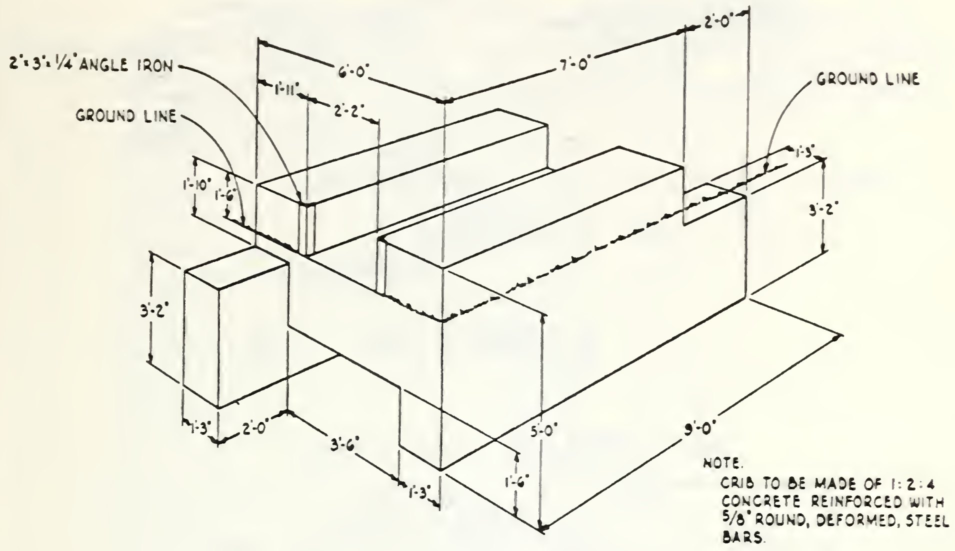
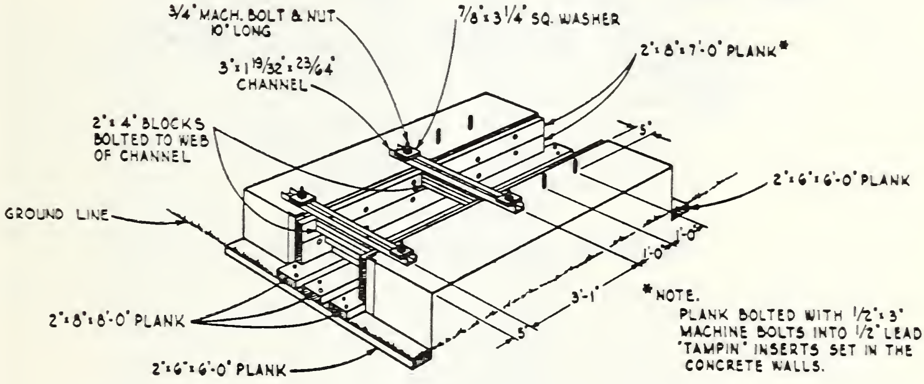


Fig. 6.—A Field Layout Which has Been Used for Pole Strength Tests.



DETAILS OF CONSTRUCTION


3/4' MACH. BOLT & NUT 10' LONG
7/8'×3 1/4' SQ. WASHER
2'×8'×7'-0' PLANK*
3'×1 19/32'×23/64' CHANNEL
2'×4' BLOCKS BOLTED TO WEB OF CHANNEL
5'
GROUND LINE
2'×6'×6'-0' PLANK
1'-0'
1'-0'
3'-1'
5'
2'×8'×8'-0' PLANK
2'×6'×6'-0' PLANK
*NOTE.
PLANK BOLTED WITH 1/2'×3'
MACHINE BOLTS INTO 1/2' LEAD
'TAMPIN' INSERTS SET IN THE
CONCRETE WALLS.

DETAILS OF CRIB FITTINGS

FIG. 7.—Pole Testing Crib Made from Concrete.

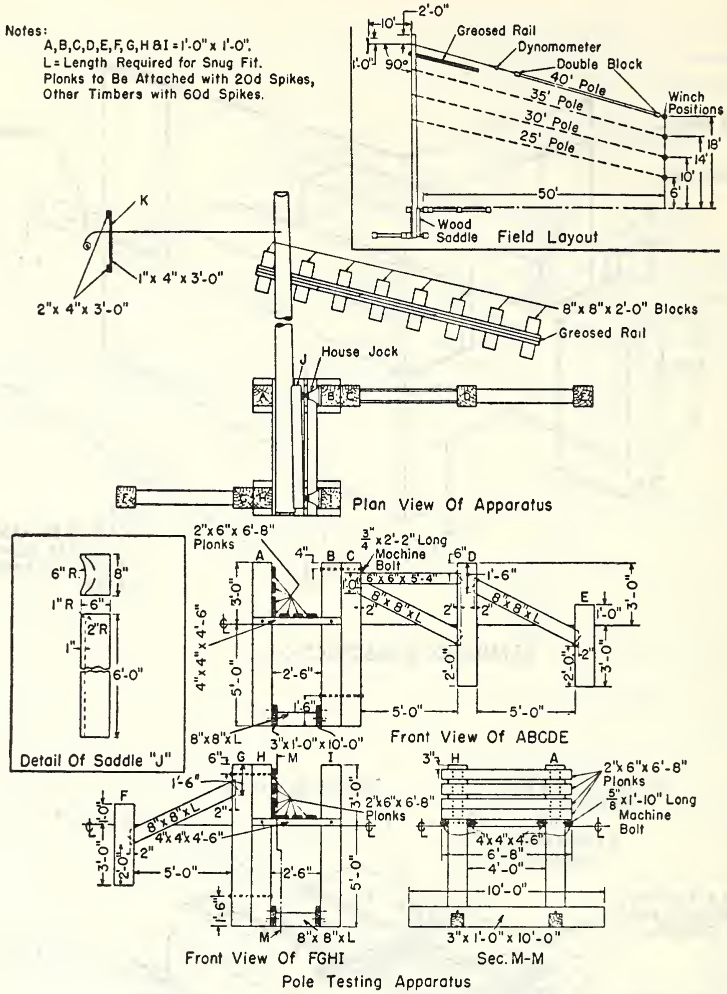
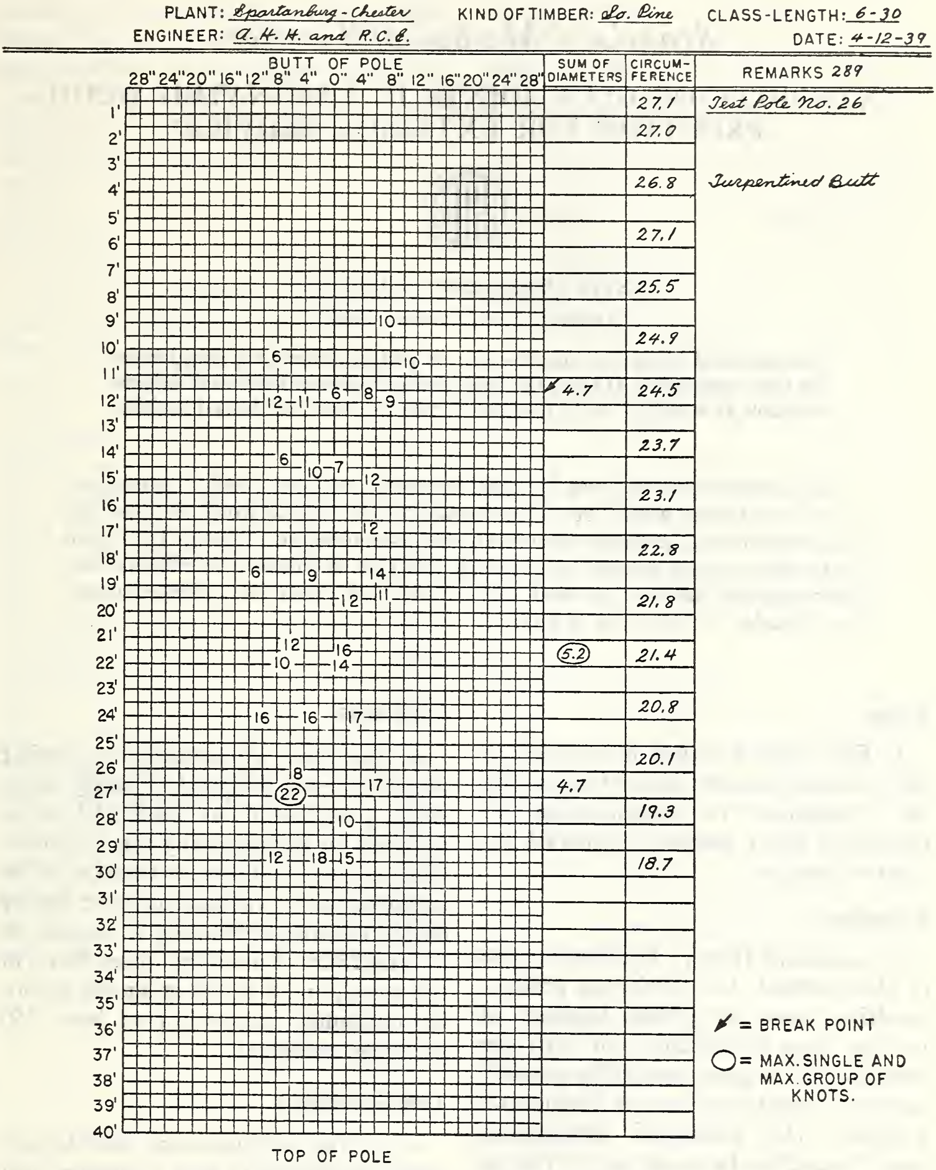


FIG. 8.—Pole Testing Crib Made from Timber.


BUTT OF POLE
28" 24" 20" 16" 12" 8" 4" 0" 4" 8" 12" 16" 20" 24" 28"
10
6
10
12
11
6
8
9
6
10
7
12
12
6
9
14
12
11
12
16
10
14
16
16
17
18
22
17
10
12
18
15
TOP OF POLE

PLANT: Spartanburg-Chester KIND OF TIMBER: So. Pine CLASS-LENGTH: 6-30

ENGINEER: A. H. H. and R. C. E. DATE: 4-12-39

	SUM OF DIAMETERS	CIRCUMFERENCE	REMARKS 289
1'		27.1	Test Pole No. 26
2'		27.0	
4'		26.8	Turpentined Butt
6'		27.1	
8'		25.5	
10'		24.9	
12'	↙ 4.7	24.5	
14'		23.7	
16'		23.1	
18'		22.8	
20'		21.8	
22'	(5.2)	21.4	
24'		20.8	
26'		20.1	
27'	4.7		
28'		19.3	
30'		18.7	

↙ = BREAK POINT

○ = MAX. SINGLE AND MAX. GROUP OF KNOTS.

FIG. 9.—Sample Form for Recording Defects.

Standard Method of Test for

INTEGRITY OF GLUE JOINTS IN LAMINATED WOOD PRODUCTS FOR EXTERIOR SERVICE[1]

ASTM Designation: D 1101 – 58

Adopted, 1953; Revised, 1958.[2]

This Standard of the American Society for Testing Materials is issued under the fixed designation D 1101; the final number indicates the year of original adoption as standard or, in the case of revision, the year of last revision.

The integrity of glue joints for glued laminated members, such as laminated arches and beams, should be at least equal to that of the wood. Because initial strength tests generally are not an adequate measure of integrity of glue joints under severe service conditions, a test that simulates the effects of exterior exposure has been devised to evaluate glue joints in laminated members intended for this type of service.

Scope

1. This method of test is intended to afford an accelerated means of measuring the resistance to delamination of laminated wood members intended for exterior service.

Definition

2. *Laminated Wood.*—For the purpose of this method, the fabricated product resulting from the gluing together of two or more laminations, all with the direction of the grain essentially parallel, to form a larger piece such as a structural member. The individual laminations may themselves be made up of two or more pieces both in width and in length.

Apparatus

3. *Autoclave.*—An autoclave or similar pressure vessel designed to safely withstand pressures of at least 150 psi is required for impregnating the specimens with water. The pressure vessel shall be equipped with a vacuum pump or similar device capable of drawing a vacuum of at least 25 in. of mercury (at sea level) in the vessel, and a pump or similar device for obtaining pressure of at least 150 psi (gage pressure).

Test Specimens

4. (*a*) The test specimens shall be prepared or selected in such a manner that they are representative of the production run or, when the test is employed to investigate new glues and procedures, the specimens shall cover fully the variables under study.

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[1] Under the standardization procedure of the Society, this method is under the jurisdiction of the ASTM Committee D-7 on Wood.

[2] Prior to adoption as standard, this method was published as tentative from 1950 to 1953.

(*b*) Each test specimen shall consist of a full cross-section of the laminated member to be tested, prepared by cutting perpendicular to the grain of the wood, and shall be 3 in. in length (along the grain). The end-grain surfaces of the specimens shall be cut with a sharp saw or other tool that produces a smooth surface.

Procedure

5. (*a*) Place the test specimens in the autoclave or pressure vessel and weight them down. Admit water, at a temperature of 75 to 85 F in sufficient quantity so that the specimens are completely submerged. Separate the specimens by stickers, wire screens, or other means in such a manner that all end-grain surfaces are freely exposed to the water. Draw a vacuum of 20 to 25 in. of mercury (at sea level) and hold it for 15 min. Then release the vacuum and apply a pressure of 150 ± 5 psi for 1 hr. With the specimens still completely immersed, repeat this vacuum-pressure cycle making a two-cycle impregnating period requiring a total of $2\frac{1}{2}$ hr. Then dry the specimens for a period of $93\frac{1}{2}$ hr in air at 80 to 85 F and 25 to 30 per cent RH, and circulating at a rate of 500 ± 50 ft per min. During drying the specimens shall be placed at least 2 in. apart and with the end-grain surfaces parallel to the stream of air. Repeat the entire soaking-drying cycle once to comprise a total test period of 8 days.

(*b*) At the end of the final drying period measure to the nearest 0.05 in. the total length of open glue joints (delamination) on the end-grain surfaces of the specimens. Failure in the wood due to checking or other causes shall not be regarded as delamination (see Appendix). Isolated delamination less than 0.10 in. long and more than 0.20 in. away from the nearest delamination shall be ignored.

(*c*) When the percentage delamination of a specimen exceeds the permissible value by less than 100 per cent of the permissible value, run the specimen through a third complete soaking-drying cycle. If at the end of the third cycle the percentage delamination does not exceed the amount allowed at the completion of two cycles by more than 100 per cent the specimen shall be considered acceptable.

Calculation and Report

6. The total length of open glue joints on the two end-grain surfaces of each specimen shall be expressed as a percentage of the entire length of the glue joints exposed on these surfaces (except that glue lines at knots and knotty areas shall be omitted). Report this value as the percentage delamination of the specimen.

APPENDIX

A1. (*a*) Delamination is a term used to express separation of the wood surfaces at the glue joints. When the separation is in the wood, even though very close to the glue joint, it is termed wood failure or checking. Magnification is often necessary to determine whether the failure is in the glue or in the wood. A feeler gage 0.003 or 0.004 in. in thickness is convenient for probing into the joint to determine if separation actually exists.

(*b*) Since glue joints at knots and knotty areas in general are not dependable under severe exposures, development of delamination at knots should be disregarded and not included in the measurements or calculations.

A2. (*a*) The test is suitable for check testing properly selected samples from regular production or for determining the suitability of glues and gluing techniques for the production of joints adequate for exterior service.

(*b*) The number of specimens taken from each member and the number of members selected for test may be varied, depending on the total number of members involved and the purpose of the tests. It is advisable, however, to include at least three specimens in the test, and the specimens should be selected to represent the probable range of quality of the glue joints.

MODIFICATION OF
TECHNICAL ASSOCIATION OF PULP AND PAPER INDUSTRY
STANDARD METHOD T 15 m-54

Standard Method of Test for

ASH IN WOOD[1]

ASTM Designation: D 1102 - 56

Adopted, 1956.[2]

This Standard of the American Society for Testing Materials is issued under the fixed designation D 1102; the final number indicates the year of original adoption as standard or, in the case of revision, the year of last revision.

Scope

1. This method is intended for the determination of ash, expressed as the percentage of residue remaining after dry oxidation (oxidation at 580 to 600 C.), of wood or wood products.

Apparatus

2. (*a*) *Crucibles.*—Crucibles with tightly fitting lids, having a capacity of 30 ml. or more, shall be used. Platinum crucibles are preferred, but silica or porcelain crucibles may be used.

(*b*) *Muffle Furnace.*—An electric furnace is recommended for igniting the wood sample. A furnace fitted with an indicating pyrometer, so that the desired temperature can be maintained, is preferable.

(*c*) An *Analytical Balance* sensitive to 0.1 mg. will be required.

(*d*) A *Drying Oven* with temperature controlled between 100 and 105 C. shall be provided.

Test Specimen

3. The test specimen shall consist of approximately 2 g. of wood that has been ground to pass a No. 40 (420-micron) sieve. Care shall be taken to ensure that it is representative of the entire lot of material being tested.

Procedure

4. (*a*) Ignite the empty crucible and cover over a burner or in the muffle at 600 C., cool in a desiccator, and weigh to the nearest 0.1 mg. Place the 2-g. test specimen in the crucible, determine the weight of crucible plus specimen, and place in the drying oven at 100 to 105 C. with the crucible cover removed. After 1 hr., replace the cover on the crucible, cool in a desiccator, and weigh. Repeat the drying and weighing until the weight is constant to within 0.1 mg. During the cooling and weighing periods, keep the crucible covered to prevent absorption of moisture from the air. Record the weight (crucible plus specimen minus weight of crucible) as the weight of the oven-dry test specimen.

(*b*) Place the crucible and contents, with the cover removed, in the muffle furnace and ignite until all the carbon is eliminated. Heat slowly at the start to avoid flaming and protect the crucible from strong drafts at all times to avoid mechanical loss of test specimen. The recommended temperature of final ignition is 580 to 600 C. Avoid heating above this maximum.

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[1] Under the standardization procedure of the Society, this method is under the jurisdiction of the ASTM Committee D-7 on Wood.

[2] Prior to adoption as standard, this method was published as tentative from 1950 to 1956.

(*c*) Remove the crucible with its contents to a desiccator, replace the cover loosely, cool, and weigh accurately. Repeat the heating for 30-min. periods until the weight after cooling is constant to within 0.2 mg.

Calculations and Report

5. (*a*) Calculate the percentage of ash, based on the weight of the moisture-free wood, as follows:

$$\text{Ash, per cent} = \frac{W_1}{W_2} \times 100$$

where:

W_1 = weight of ash, and

W_2 = weight of oven-dry sample

(*b*) Report the results to two decimal places.

Precision

6. Duplicate determinations should agree within 0.05 per cent.

Tentative Method of Test for

ALPHA-CELLULOSE IN WOOD[1]

ASTM Designation: D 1103 - 55 T

Issued, 1950; Revised, 1955.[2]

This Tentative Method has been approved by the sponsoring committee and accepted by the Society in accordance with established procedures, for use pending adoption as standard. Suggestions for revisions should be addressed to the Society at 1916 Race St., Philadelphia 3, Pa.

Scope

1. This method is intended for the determination of alpha-cellulose in wood.

Principle of Method

2. Alpha-cellulose must be determined on an extractive-free, lignin-free wood residue. Since wood is highly lignified, it is accordingly necessary first to subject the material to preliminary treatments to render it amenable to the procedure for alpha-cellulose determination. The extractives are first removed from the wood sample, after which the lignin is removed from the extractive-free wood, leaving a finely divided, porous, white, solid residue of holocellulose, which consists of the hemicellulose and the cellulose of the original wood. The holocellulose is treated with sodium hydroxide and then with acetic acid, and the dried residue is weighed as alpha-cellulose.

Apparatus

3. (*a*) *Constant-Temperature Device.*—A thermostat or other constant-temperature device will be required that will maintain a temperature of 20 ± 0.1 C in a container large enough to hold a row of at least three 250-ml beakers, kept in an upright position at all times (Note).

Note.—A shallow pan, provided with an inlet tube for running water adjustable as to specified temperature, and provided with an overflow tube to maintain a depth of approximately $\frac{1}{2}$ in. of water, has been used for this purpose.

(*b*) *Filtering Crucibles*, of alundum or fritted glass of medium porosity.

Reagents

4. (*a*) *Sodium Hydroxide Solution* (*17.5 ± 0.1 per cent*) (Note 1).

Note 1.—The NaOH solution (17.5 per cent), practically free of carbonate, can be conveniently prepared by diluting NaOH solution (50 per cent) with distilled water free of CO_2. The NaOH solution (50 per cent) may be kept as a stock solution. Sodium carbonate and other insoluble impurities settle out. The supernatant clear solution is diluted to prepare the 17.5 per cent solution, the concentration of which shall be 17.5 ± 0.1 per cent of NaOH hydroxide, equivalent to a density of 1.194 ± 0.001 at 15 C or 1.192 ± 0.001 at 20 C.[3]

(*b*) *Sodium Hydroxide Solution* (*8.3 per cent*) (Note 2).

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[1] Under the standardization procedure of the Society, this method is under the jurisdiction of the ASTM Committee D-7 on Wood.

[2] Revision accepted by the Society at the Annual Meeting, June, 1955.

[3] International Critical Tables, Vol. III, p. 79.

NOTE 2.—The NaOH solution (8.3 per cent) may be prepared by diluting NaOH solution (50 per cent) with distilled water to a density of 1.092 ± 0.001 at 15 C, or 1.090 ± 0.001 at 20 C; or the proper degree of dilution may be obtained as described in Note 2 of Section 6.

(*c*) *Acetic Acid* (*10 per cent*).—Mix 1 part by weight of glacial acetic acid with 9 parts of distilled water.

Test Specimen

5. The test specimen shall consist of 2 g of wood that has been ground to pass a No. 60 (250-micron) sieve and be retained on a No. 80 (177-micron) sieve, and then thoroughly air-dried.

Procedure

6. (*a*) At the same time the test specimen is weighed, weigh an additional 2-g portion of the air-dry, ground wood into a tared, glass-stoppered weighing bottle. Dry in an oven for 2 hr at 100 to 105 C, replace the stopper, and cool in a desiccator. Loosen the stopper to equalize the pressure and weigh. Continue the drying for 1-hr periods until the weight is constant. Calculate the percentage of moisture-free wood.

(*b*) Remove the extractives from the wood sample in accordance with the Method for Preparation of Extractive-free Wood (ASTM Designation: D 1105).[4] Next, remove the lignin from the extractive-free wood in accordance with the procedure described in the Method of Test for Holocellulose in Wood (ASTM Designation: D 1104).[4] Air-dry the holocellulose that has thus been isolated from the wood.

(*c*) Transfer quantitatively the specimen of air-dry holocellulose to a 250-ml chemically resistant glass beaker provided with a cover glass (Note 1).

NOTE 1.—The time consumed in making alpha-cellulose determinations by this method is efficiently utilized if test specimens are run in groups of two. Allowing an interval of 20 min between specimens at the beginning of the caustic treatment, that is, when the NaOH solution (17.5 per cent) is added to the air-dry sample, provides ample time for the various subsequent steps in the analysis.

(*d*) Carefully measure 25 ml of NaOH solution (17.5 per cent) in a graduate, and adjust to and maintain at 20 C. Add 10 ml of the NaOH solution to the holocellulose in the 250-ml beaker, which shall be maintained at 20 C in the water bath, and cover with a watch glass. Manipulate the holocellulose lightly with a glass rod having a flattened end (1 cm in diameter) so that all of the specimen will become soaked with the NaOH solution. After 2 min, manipulate the specimen with the glass rod by pressing and stirring until the particles are separated from one another. Five minutes after the addition of the first portion of NaOH solution (17.5 per cent) to the specimen, add 5 ml more of the NaOH solution and thoroughly stir the mixture with the glass rod. After another 5 min, add another 5 ml of the NaOH solution and stir. Fifteen minutes after addition of the first portion of NaOH, add the remaining 5 ml portion of NaOH solution, and stir again with the glass rod. Allow the mixture to stand at 20 C for 30 min, making the time for total NaOH treatment 45 min.

(*e*) When the 45-min caustic treatment is complete, add 33 ml of distilled water at 20 C to the mixture (Note 2). Thoroughly mix the contents of the beaker, which has remained in the beaker from the beginning, and allow to stand at 20 C for 1 hr before filtering.

NOTE 2.—The addition of 33 ml of water to the original 25 ml of NaOH solution (17.5 per cent) reduces the concentration to 8.3 per cent of NaOH.

(*f*) Filter the cellulose with the aid of suction into the tared, alkali-resistant alundum or fritted-glass crucible (Note 3) of medium porosity. Transfer all the holocellulose residue to the crucible, and wash with 100 ml of NaOH solution (8.3 per cent) at 20 C. After the NaOH wash solution has passed through the residue in the crucible, continue the washing at 20 C with distilled water, making certain that all particles have been transferred from the 250-ml beaker to the crucible. Washing the pulp in the crucible is facilitated by releasing the suction, filling the crucible to within ¼ in. of the top with water, carefully breaking up the cellulose mat with a glass rod so as to separate any lumps present, and again applying suction. Repeat this step twice. The combined filtrate at this stage of the procedure may be set aside for the determination of beta-cellulose.

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[4] Appears in this publication, see Contents in Numeric Sequence of ASTM Designations at front of book.

Note 3.—Fritted-glass crucibles should always be weighed in closed weighing bottles. The crucibles may be cleaned of cellulosic material by immersing them overnight in a strong cleaning solution of $Na_2Cr_2O_7$ and H_2SO_4, rinsing them with water, and washing them by suction with distilled water. Dry the crucible and its empty and uncovered weighing bottle in an oven at 100 to 105 C for not less than 3 hr. Immediately before removal from the oven, transfer the crucible to the weighing bottle, and loosely close the bottle with its lid. Cool the closed assembly of weighing bottle and crucible in a desiccator to room temperature and weigh.

(*g*) Pour 15 ml of acetic acid (10 per cent) at room temperature into the crucible, drawing the acid into the cellulose by suction but, while the cellulose is still covered with acid, release the suction. Subject the cellulose to the acid treatment for 3 min from the time the suction is released; then apply suction to draw off the acetic acid. Without releasing the suction, fill the crucible almost to the top with distilled water at 20 C and allow to drain completely. Repeat the washing until the cellulose residue is free of acid (Note 4). Give the cellulose a final washing by drawing by suction an additional 250 ml of distilled water through the cellulose in the crucible.

Note 4.—Make the test indicating the absence of acid from the washed pulp with blue litmus paper. Allow the crucible to drain, release the suction, remove the crucible from the holder, and apply the litmus paper to the liquid adhering to the inside of the crucible beneath the fritted glass, or at the bottom of the crucible if of alundum.

(*h*) Dry the crucible on the bottom and sides with a cloth and then, together with the weighing bottle in which the wood was originally weighed, place it overnight in an oven to dry at 100 to 105 C. Before the crucible is removed from the drying oven, place it in its weighing bottle, and close the bottle with its lid. Cool the crucible and weighing bottle in a desiccator for 1 hr before weighing (Note 5).

Note 5.—The alpha-cellulose content of several American woods, on the preceding basis, has been found to range from 46 to 53 per cent, depending on the species.

Calculation and Report

7. (*a*) Calculate the percentage of alpha-cellulose on the basis of the oven-dry wood sample, as follows:

$$\text{Alpha-cellulose, per cent} = \frac{W_2}{W_1} \times 100$$

where:

W_2 = weight of the oven-dry alpha-cellulose residue, and

W_1 = weight of the original oven-dry wood sample.

(*b*) Report the results to the first decimal place.

Precision

8. The alpha cellulose values of duplicate wood specimens should agree within 0.80 per cent.

Note.—If desirable to report the alpha-cellulose on an ash-free basis, the dried and weighed alpha-cellulose residue may be ashed by the usual procedure.

Standard Method of Test for

HOLOCELLULOSE IN WOOD[1]

ASTM Designation: D 1104 – 56

Adopted, 1956.[2]

This Standard of the American Society for Testing Materials is issued under the fixed designation D 1104; the final number indicates the year of original adoption as standard or, in the case of revision, the year of last revision.

Scope

1. This method is intended for the determination of holocellulose (hemicellulose plus cellulose) in wood.

Apparatus

2. The apparatus shall consist of the following:

(*a*) *Filtering Crucibles.*—Alundum or fritted-glass crucibles of medium porosity.

(*b*) *Suction Flasks.*

(*c*) *Erlenmeyer Flasks.*

Reagents

3. (*a*) *Ethyl Alcohol (95 per cent).*

(*b*) *Alcohol - Monoethanolamine Solution.*—Mix 97 volumes of ethyl alcohol (95 per cent) and 3 volumes of monoethanolamine.

(*c*) *Ethyl Ether.*

(*d*) *Chlorine Gas.*

Test Specimen

4. The test specimen shall consist of 2.0 g. of extractive-free 60- to 80-mesh wood meal that has been prepared in accordance with the Method for Preparation of Extractive-Free Wood (ASTM Designation: D 1105).[3]

Procedure

5. (*a*) Weigh accurately in a tared alundum or fritted-glass crucible about 2.0 g. of the air-dry extractive-free wood whose moisture content is known. Moisten the material with cold distilled water at 10 C. and remove the excess moisture by suction.

(*b*) Using moderate suction, chlorinate the sample by passing the gas through a funnel inverted over the crucible, which is held in position on a suction flask. After 3 min. of chlorination, remove the inverted funnel, stir the meal thoroughly, and rechlorinate for 2 min.

(*c*) Add alcohol to dissolve excess chlorine and HCl formed during chlorination and after 1 min. remove by suction. Release the vacuum, add sufficient hot alcohol - monoethanolamine solution to cover the wood completely, and stir thoroughly. Allow the solution to stand 2 min.; then remove it by suction. Repeat the solvent treatment. Remove any remaining solvent by washing twice with 95 per cent ethyl alcohol and twice with cold water. Remove excess water by suction.

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[1] Under the standardization procedure of the Society, this method is under the jurisdiction of the ASTM Committee D-7 on Wood.

[2] Prior to adoption as standard, this method was published as tentative from 1950 to 1956.

[3] See p. 146.

(*d*) Repeat the chlorination and extraction treatments until the residue becomes white following chlorination and is no longer colored by the addition of the hot alcohol - monoethanolamine solution. Remove the alcohol - monoethanelamine by washing twice with alcohol, twice with cold water (10 C.), and again with alcohol until the residue is neutral to litmus. Finally, wash with ether to facilitate drying.

(*e*) Air-dry the holocellulose to remove excess ether and then dry to constant weight in an oven at 105 C.

Report

6. Calculate the percentage of holocellulose based on the weight of moisture-free, extractive-free wood. If the percentage of the extractives in the wood has been previously determined, the percentage of holocellulose can be reported on the weight of the oven-dry unextracted wood.

Standard Method for

PREPARATION OF EXTRACTIVE-FREE WOOD[1]

ASTM Designation: D 1105 – 56

Adopted, 1956.[2]

This Standard of the American Society for Testing Materials is issued under the fixed designation D 1105; the final number indicates the year of original adoption as standard or, in the case of revision, the year of last revision.

Scope

1. This method is intended for preparation of extractive-free wood and is applicable to all North American woods. Extractives in wood consist of materials that are soluble in neutral solvents and that are not a part of the wood substance.

Apparatus

2. *Soxhlet Extraction Apparatus.*—A glass Soxhlet extraction apparatus of suitable size for containing the sample, and fritted-glass or alundum extraction thimbles of medium to coarse porosity, will be required. Bags of cotton cloth of fine weave and thoroughly washed, of a suitable size to fit within the body of the extractor, are also satisfactory in place of the thimbles. Alternatively, a small wad of cotton or a wire screen may be placed in the discharge tube of the extractor and the entire body of the extractor filled with the wood sample. A thin wire screen disk placed over the top of the material will prevent channelling by the dripping condensate.

Reagents

3. (*a*) *Ethyl Alcohol* (*95 per cent*).

(*b*) *Alcohol - Benzene Mixture.*—Mix one volume of ethyl alcohol (95 per cent) and two volumes of c. p. benzene.

Sample

4. The sample shall consist of air-dry sawdust that has been reduced by means of a Wiley mill so as to pass through a No. 60 (250-micron) sieve and be retained on a No. 80 (177-micron) sieve.

Procedure

5. (*a*) Place a suitable quantity of the sample in the extraction thimble, being certain that the wood does not extend above the level of the top of the siphon tube. Extract for 4 hr. with alcohol - benzene mixture in the Soxhlet extraction apparatus. Transfer the wood to a Büchner funnel, remove the excess solvent with suction, and wash the thimble and wood with alcohol to remove the benzene. Return the wood to the extractor and continue the extraction with 95 per cent alcohol for 4 hr., or longer if necessary, until the alcohol siphons over colorless.

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[1] Under the standardization procedure of the Society, this method is under the jurisdiction of the ASTM Committee D-7 on Wood.

[2] Prior to adoption as standard, this method was published as tentative from 1950 to 1956.

(*b*) If the thimble is nearly full, a Gooch crucible of suitable size may be placed in the rim of the thimble to keep the sample together. Extraction with each solvent should be carried out at a rate of not less than four siphonings per hour. Remove the wood from the thimble, spread it out in a thin layer, and allow it to dry in the air until free of alcohol. Transfer the material to a 1-liter Erlenmeyer or Florence flask and extract successively with three 1-liter portions of distilled water, heating the flask with each change of water for 1 hr. in a hot-water bath at 100 C. The water should be at boiling temperature before the addition of the wood and the flask in the bath should be entirely surrounded by the boiling water. After the third extraction with water is complete, filter on a Büchner funnel, wash with 500 ml. of boiling distilled water, and allow the extracted material to become thoroughly dry in the air.

TECHNICAL ASSOCIATION OF PULP AND PAPER INDUSTRY
STANDARD METHOD T 13 m-54

Standard Method of Test for
LIGNIN IN WOOD[1]

ASTM Designation: D 1106 – 56

Adopted, 1956.[2]

This Standard of the American Society for Testing Materials is issued under the fixed designation D 1106; the final number indicates the year of original adoption as standard or, in the case of revision, the year of last revision.

Scope

1. This method[3] is intended for the determination of the lignin content of wood.

Principle of Method

2. (*a*) When wood is treated with strong acids the carbohydrates are hydrolyzed, leaving an insoluble residue which is determined as lignin. Since some of the wood extractives (oils, resins, fats, waxes, tannins, gums, and starch) would remain insoluble with the lignin, these are first removed by proper solvents. The 72 per cent sulfuric acid method for lignin contains two and sometimes three preliminary extractive treatments, namely: (*1*) with alcohol, to remove the catechol tannins; (*2*) with alcohol - benzene solution, to remove the resins, oils, fats and waxes; and (*3*) with hot water, to remove the remaining water-soluble materials.

(*b*) The alcohol extraction is necessary in analysis of woods high in tannin; that is, oak, chestnut, redwood, etc. It has not been shown necessary in the more common pulpwoods, such as the various species of spruce, pine, fir, hemlock, poplar, birch, beech, and maple. It is recommended that for these woods the alcohol extraction be omitted unless it is desirable for a special purpose. In analysis of woods not listed, the desirability of the alcohol extraction depends upon the purpose of the analysis and the report should state whether or not alcohol extraction was used.

Apparatus

3. (*a*) *Extraction Apparatus.*—A compact form of Soxhlet extraction apparatus, with ground-glass joints, is preferable. The apparatus shall consist of the following items:

(*1*) *Soxhlet Extraction Flask* having a capacity of 250-ml.

(*2*) *Soxhlet Extraction Tube,* 45 to 50 mm. in inside diameter, having a capacity to the top of the siphon of approximately 100 ml. and a siphon tube approximately 55 mm. in height. Extraction tubes of these dimensions siphon more rapidly than extractors with higher siphon tubes.

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[1] Under the standardization procedure of the Society, this method is under the jurisdiction of the ASTM Committee D-7 on Wood.

[2] Prior to adoption as standard, this method was published as tentative from 1950 to 1956.

[3] For further information on this method the following references may be consulted:

M. W. Bray, "Methods Used at the Forest Products Laboratory for the Chemical Analysis of Pulps and Pulpwoods," *Paper Trade Journal*, Vol. 87, No. 25, December 20, 1928, p. 29.

G. J. Ritter, R. M. Seborg, and R. L. Mitchell, *Industrial and Engineering Chemistry*, Analytical Edition, Vol. 4, p. 202 (1932).

G. J. Ritter, and J. H. Barbour, *Industrial and Engineering Chemistry*, Analytical Edition, Vol. 7, p. 238 (1935).

(*3*) *Condenser* of the Hopkins inner-cooled type.

(*4*) *Extraction Crucibles* of alundum or fritted glass and of medium or fine porosity.

(*b*) *Filtering Crucibles.*—Alundum, porous porcelain, or fritted-glass crucibles (all of fine porosity), or Gooch crucibles with an acid-washed asbestos mat, are recommended for filtering the separated lignin. Glass crucibles cannot be used if the lignin is to be ashed.

Reagents

4. (*a*) *Alcohol - Benzene Solution.*—Mix one volume of ethyl alcohol (95 per cent) and two volumes of c.p. benzene.

(*b*) *Sulfuric Acid (72 per cent).*—Carefully pour 665 ml. of H_2SO_4 (sp. gr. 1.84) into about 300 ml. of water, with vigorous stirring, and, after cooling, dilute to 1 liter. Standardize against standard NaOH solution, using methyl orange indicator. Adjust the H_2SO_4 to a strength of 72 ± 0.1 per cent by addition of water or H_2SO_4 (sp. gr. 1.84) as may be found necessary.

If desired, the solution may be standardized by an accurate determination of its specific gravity. For 72 per cent H_2SO_4 the specific gravity at 20/4 C. is 1.6338; for use of this specific gravity method appropriate tables should be consulted.

Test Specimen

5. The test specimen shall consist of 1 g. of wood that has been ground to pass a No. 40 (420-micron) sieve and thoroughly air-dried.

Procedure

6. (*a*) Weigh two 1-g. test specimens in tared glass-stoppered weighing bottles. Dry in an oven for 2 hr. at 100 to 105 C., replace the stopper, and cool in a desiccator. Loosen the stopper to equalize the pressure and weigh. Continue the drying for 1-hr. periods until the weight is constant. Calculate the percentage of moisture-free wood.

(*b*) Weigh in the extraction crucibles two additional 1-g. test specimens for the lignin determination in duplicate. Place the extraction crucible containing the specimen in a Soxhlet extraction apparatus. Extract with 95 per cent alcohol for 4 hr., unless the wood is known not to contain catechol tannins, in which case this extraction with alcohol will not be required. Then extract the test specimen with alcohol - benzene solution as described in the Method of Test for Alcohol - Benzene Solubility of Wood (ASTM Designation: D 1107).[4] Remove as much of the solvent by suction as possible and wash by suction with 50 ml of alcohol to remove the benzene. Remove the excess alcohol, transfer to a beaker, and digest with 400 ml. of hot water in a steam or hot-water bath at approximately 100 C. for 3 hr. Filter, wash with 100 ml. of hot water, and finally with 50 ml. of alcohol to facilitate the removal of the test specimen from the crucible. After these preliminary extractions, let the specimen dry in the air.

(*c*) Transfer the air-dried test specimen to a glass-stoppered weighing bottle or a small beaker with a glass cover and add slowly, while stirring, 15 ml. of cold (12 to 15 C.) H_2SO_4 (72 per cent). The specimen shall be well mixed with the acid by stirring constantly for at least 1 min. Allow to stand for 2 hr., with frequent stirring, at a temperature of 18 to 20 C. A water bath may be necessary to keep the temperature within these limits. Wash the material into a 1-liter beaker or Erlenmeyer flask, dilute to a 3 per cent concentration of H_2SO_4 by adding 560 ml. of distilled water, and boil for 4 hr., either under a reflux condenser or in a nearly constant volume condition maintained by the occasional addition of hot water to the flask.

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[4] See p. 156.

(*d*) After allowing the insoluble material to settle, filter into a filtering crucible that has been dried at 100 to 105 C. and weighed in a glass-stoppered weighing bottle. Wash the residue free of acid with 500 ml. of hot water and dry the crucible and contents in an oven for 2 hr. at 100 to 105 C. Place in the weighing bottle, cool in a desiccator, loosen the stopper of the bottle, and weigh the contents of the crucible as lignin. Repeat the drying and weighing until the weight is constant.

(*e*) If a correction for ash is desired, transfer the lignin to a tared platinum crucible and determine the ash by igniting at 900 C. If the lignin cannot be quantitatively transferred, it may be ashed in the filtering crucible, provided the latter has been ignited to constant weight before filtration of the lignin residue. Ignition cannot be performed in fritted-glass crucibles.

Report

7. Report the results as percentage by weight of lignin in moisture-free unextracted wood. If the wood was extracted with alcohol or if the lignin was corrected for ash, state this in the report.

MODIFICATION OF
TECHNICAL ASSOCIATION OF PULP
AND PAPER INDUSTRY
STANDARD METHOD T 2 m-43

Tentative Method of Test for
METHOXYL GROUPS IN WOOD AND RELATED MATERIALS[1]

ASTM Designation: D 1166 – 55 T

ISSUED, 1951; REVISED, 1955.[2]

This Tentative Method has been approved by the sponsoring committee and accepted by the Society in accordance with established procedures, for use pending adoption as standard. Suggestions for revisions should be addressed to the Society at 1916 Race St., Philadelphia 3, Pa.

Scope

1. This method is intended for the determination of methoxyl groups in wood and related materials (**1** to **7**).[3] The method is applicable to wood sawdust and, by suitable adjustment in size of the test specimen, to fractions isolated from wood and lignin.

Principle of Method

2. The principle of the method is the same as that in the original method of Zeisel (**1**), except that the methyl iodide is collected in an acetic acid solution of potassium acetate containing bromine. The following reactions then occur:

$$CH_3I + Br_2 \rightarrow CH_3Br + IBr$$
$$IBr + 2Br_2 + 3H_2O \rightarrow HIO_3 + 5HBr$$

The iodic acid is determined by titration of iodine liberated by the reaction:

$$HIO_3 + 5HI \rightarrow 3I_2 + 3H_2O$$

From the above equations, it follows that one methoxyl group (CH_3O) liberates six atoms of iodine.

Apparatus

3. The apparatus shall be similar to that illustrated in Fig. 1 and shall consist of the following:

(*a*) *Reaction Flask.*

(*b*) *Heat Source.*—A microburner, provided with a cylindrical shield to eliminate the effect of air drafts.

(*c*) *Vertical Air-Cooled Condenser.*

(*d*) *Scrubber.*

(*e*) *Two Absorption Vessels.*

Purity of Reagents and Water

4. (*a*) *Reagents.*—Unless otherwise indicated, it is intended that all reagents shall conform to the specification of the Committee on Analytical Reagents of the American Chemical Society, where such specifications are available.[4] Other

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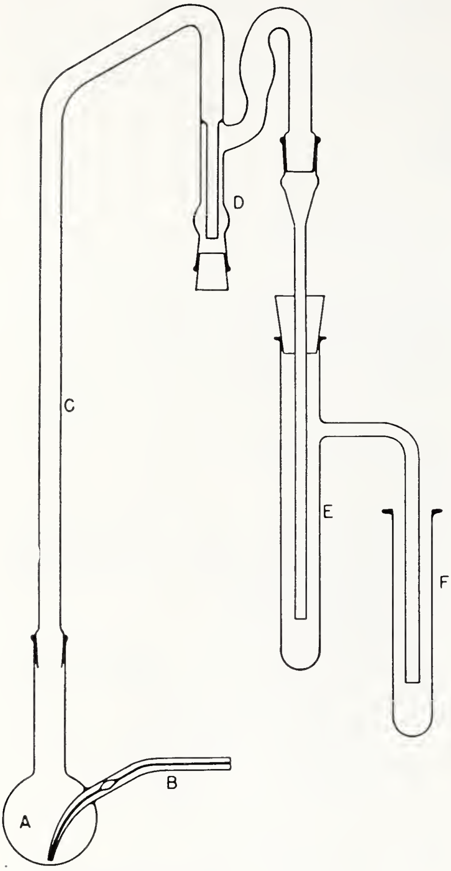
[1] Under the standardization procedure of the Society, this method is under the jurisdiction of the ASTM Committee D-7 on Wood.

[2] Revision accepted by the Society at the Annual Meeting, June, 1955.

[3] The boldface numbers in parentheses refer to the references listed at the end of this method.

[4] "Reagent Chemicals, American Chemical Society Specifications," Am. Chem. Soc., Washington, D. C. For suggestions on the testing of reagents not listed by the American Chemical Society, see "Reagent Chemicals and Standards," by Joseph Rosin, D. Van Nostrand Co., Inc., New York, N. Y., and the "United States Pharmacopoeia."

grades may be used, provided it is first ascertained that the reagent is of sufficiently high purity to permit its use without lessening the accuracy of the determination.



A—Reaction flask.
B—CO_2 inlet tube.
C—Vertical air-cooled condenser.
D—Trap or scrubber.
E and *F*—Absorption vessels or receivers.

FIG. 1.—Apparatus for Methoxyl Determination.

(*b*) *Water.*—Unless otherwise indicated, references to water shall be understood to mean distilled water.

Reagents

5. (*a*) *Hydriodic Acid* (*sp gr 1.70*).—The best reagent grade HI, if stored in the absence of light and at a low temperature, may be used without redistillation. If purification is necessary, the HI may be redistilled after addition of a few grams of red phosphorus, taking care not to overheat the sides of the flask above the liquid level, and collecting the distillate which comes over between 124 and 130 C. A slow stream of CO_2 should be maintained through the receiver during the distillation (**Caution,** Note 1). A permanently colorless solution of hydriodic acid may be obtained if the liquid, heated to approximately 100 C, is treated with slightly more than the quantity of H_3PO_2 (50 per cent) necessary to effect complete decolorization.

NOTE 1: **Caution.**—During the distillation, the poisonous gas phosphine, PH_3, may be formed under certain conditions, and this may unite with molecular iodine to form the explosive PI_3, similar in properties to NI_3. The PI_3 may explode on contact with air. It is therefore advisable to keep the current of CO_2 going after the distillation has been finished, until the apparatus has cooled; this prevents air from being sucked into the apparatus. As a safety precaution, the distillation should be conducted in a hood or behind a wire-glass shield.

(*b*) *Phenol.*

(*c*) *Cadmium Sulfate Solution* (*50 g $CdSO_4$ per l*).—Dissolve 67.2 g of $CdSO_4 \cdot 4H_2O$ in water and dilute to 1 liter (Note 2).

NOTE 2.—A water suspension of red phosphorus is equally satisfactory in the scrubber.

(*d*) *Sodium Thiosulfate Solution* (*50 g $Na_2S_2O_3$ per l*).—Dissolve 78.5 g of $Na_2S_2O_3 \cdot 5H_2O$ in water and dilute to 1 liter (Note 2).

(*e*) *Carbon Dioxide Gas.*—The CO_2 may be drawn from a cylinder of the compressed gas. It may be obtained also by the use of a Kipp generator and washed, before introduction into the apparatus, through two wash bottles, the first containing saturated $NaHCO_3$ solution and the second containing

H_2SO_4 (sp gr 1.84). Solid CO_2, or "dry ice," is a convenient source (5) and the gas requires no purification.

(*f*) *Potassium Acetate Solution in Acetic Acid.*—Dissolve 100 g of anhydrous potassium acetate in 1 liter of glacial acetic acid. Traces of moisture are not significant.

(*g*) *Liquid Bromine.*

(*h*) *Sodium Acetate Solution* (*250 g per l*).—Dissolve 415 g of sodium acetate trihydrate in water and dilute to 1 liter.

(*i*) *Formic Acid* (*90 per cent*).

(*j*) *Potassium Iodide Solution* (*100 g KI per l*).—Dissolve 100 g of KI in water and dilute to 1 liter (Note 3).

NOTE 3.—The KI solution, on standing, develops a yellow color due to free iodine. If a blank titration on the solution consumes $Na_2S_2O_3$, a fresh solution should be prepared.

(*k*) *Sulfuric Acid* (*1:9*).—Mix one volume of H_2SO_4 (sp gr 1.84) with nine volumes of water.

(*l*) *Standard Sodium Thiosulfate Solution* (*0.1 N*).—Dissolve 25 g of $Na_2S_2O_3 \cdot 5H_2O$ in 200 ml of water and dilute to 1 liter. Use freshly boiled and cooled water. It is preferable to allow the solution to stand for a few days before standardization.

Standardize the solution against an approximately 0.1 N solution of $KMnO_4$ that has been standardized against sodium oxalate oxidimetric standard furnished by the National Bureau of Standards (standard sample No. 40). In each of two glass-stoppered Erlenmeyer flasks put 2 g of KI and 100 ml of freshly boiled and cooled water. Shake to dissolve the KI and add 2 ml of HCl (sp gr 1.18). To one flask add slowly from a buret either 20.0 ml of 0.1 N $KMnO_4$ or 10.0 ml of 0.18 N $KMnO_4$, while swirling the flask gently. To the other flask add an equal volume of water. Stopper the flasks and let them stand in the dark for 10 min. Titrate the iodine that has been set free with the $Na_2S_2O_3$ until the solution is of a faint straw color. Add 2 ml of starch solution and continue the titration until the blue color has just been destroyed. Subtract the volume of $Na_2S_2O_3$ required in the blank determination from that required in the other titration, and calculate the normality of the $Na_2S_2O_3$, based on the normality of the $KMnO_4$.

(*m*) *Starch Indicator Solution* (*10 g per l*).—Make a paste of 1 g of soluble starch in 5 ml of water and add to 100 ml of boiling water. Prepare fresh as needed.

Test Specimen

6. (*a*) The test specimen of wood shall consist of about 0.1 g, weighed to the nearest 0.0001 g, of air-dry sawdust that has been ground to pass a No. 40 (420-micron) sieve. For analysis of isolated lignins or other preparations of high methoxyl content, it is recommended that the specimen not exceed 0.05 g. For specimens of very low methoxyl content, the specimen may be increased to 0.2 g.

(*b*) The specimen may be weighed in a glass boat, in a gelatin capsule, or on a cigarette paper. The container shall be transferred with the specimen to the reaction flask. The paper or capsule shall contain no methoxyl groups, as determined by a separate analysis.

Moisture Determination

7. At the same time the test specimen is weighed, weigh 0.1 g of the air-dry sawdust in a tared, glass-stoppered weighing bottle. Dry in an oven for 2 hr at 100 to 105 C, replace the stopper, and cool in a desiccator. Loosen the stopper to equalize the pressure and weigh. Continue the drying for 1-hr periods until the weight is constant. Calculate the percentage of moisture-free wood.

Procedure

8. (*a*) Place in the reaction flask 15 ml of HI, 7 g of phenol, and a 1-cm length of Nichrome wire or a boiling tube (Note 1) to prevent bumping. Place in the scrubber a mixture of equal volumes of $CdSO_4$ solution (50 g $CdSO_4$ per l) and $Na_2S_2O_3$ solution (50 g $Na_2S_2O_3$ per l) (see Note 2 under Section 5). The volume of solution should be adjusted so that the inlet tube of the scrubber is covered to a depth of about 4 mm. Adjust the flow of CO_2 to about 60 bubbles per minute through the scrubber. (Note 2.)

NOTE 1.—A boiling tube may be prepared by sealing off a piece of thin-wall capillary tubing of such length that it will remain vertical in the reaction flask, and inserting it with the open end down. If the CO_2 introduction tube extends to the bottom of the flask, no anti-bumping device is necessary.

NOTE 2.—Two to four samples may be analyzed with one charge of reagents in the reaction flask and scrubber. The apparatus should then be thoroughly cleaned.

(*b*) Bring the contents of the flask to reaction temperature. Adjust the rate of heating so that the vapors of the boiling HI rise about 10 cm into the condenser. Heat the flask at reaction temperature for 30 to 45 min, or longer if necessary, to remove methoxyl-containing or other interfering substances which are usually present in the reagents (Note 3).

NOTE 3.—An appreciable blank may arise from the reagents used. The greater part of this blank is removed by a preliminary "burning out" period. In normal work, the time required to remove interfering substances must be determined by a trial determination, in the absence of a test specimen, for a particular lot of reagents. For the highest accuracy, it is recommended that the residual blank be ascertained by "blank" determinations before and after the determination on the test specimen. These blank determinations are made in the normal manner and their average is subtracted from the titration of the sample.

(*c*) Let the reaction flask cool below 100 C. In the meantime, add to 20 ml of the potassium acetate solution, about 0.6 ml of bromine, and mix. Add approximately 15 ml of the mixture to the first receiver and 5 ml to the second, and attach the receivers to the apparatus. Seal the ground-glass joint with a small drop of water from a glass rod.

(*d*) Remove the distilling flask and introduce the test specimen. Immediately reconnect the flask and seal the ground-glass joint with a drop of molten phenol from a glass rod. Bring the contents of the flask to reaction temperature while passing a uniform stream of CO_2 through the apparatus. Adjust the rate of heating so that the vapors of the boiling HI rise about 10 cm into the condenser. Continue the heating for a time sufficient to complete the reaction and sweep out the apparatus. Usually, not more than 50 min are required.

(*e*) Wash the contents of both receivers into a 250-ml Erlenmeyer flask that contains 15 ml of sodium acetate solution. Dilute with water to approximately 125 ml and add 6 drops of formic acid. Rotate the flask until the color of the bromine is discharged, then add 12 more drops of formic acid and allow the solution to stand for 1 to 2 min. Add 10 ml of KI solution and 10 ml H_2SO_4 (1:9), and titrate the liberated iodine with $Na_2S_2O_3$ solution, adding 1 ml of starch indicator solution just before the end point is reached and continuing the titration to the disappearance of the blue color.

Calculation and Report

9. (*a*) Calculate the percentage of methoxyl groups, based on the weight of moisture-free wood, as follows:

Methoxyl, per cent

$$= \frac{VN \times 31.03 \times 100}{G \times 1000 \times 6} = \frac{VN}{G} \times 0.517$$

where:

V = milliliters of $Na_2S_2O_3$ solution required for the titration,

N = normality of $Na_2S_2O_3$ solution, and

G = grams of moisture-free wood in the test specimen.

(*b*) Report the results to the second decimal place.

REFERENCES

(1) S. Zeisel, "Quantitative Estimation of Methoxyl," *Monatshefte für chemie,* Vol. 6, p. 989 (1885); Vol. 7, p. 406 (1886).

(2) A. Friedrich, "Micromethoxyl Determination," *Zeitschrift für Physiologische Chemie,* Vol. 163, p. 148 (1927).

(3) E. P. Clark, "The Action of Boiling Hydriodic Acid as Used in the Zeisel Method upon Gossypol and Some of Its Derivatives. A Semimicro Zeisel Methoxyl Method," *Journal,* Am. Chemical Soc., Vol. 51, p. 1479 (1929).

(4) F. Vieböck and A. Schwappach, "New Method for the Volumetric Determination of the Methoxyl and Ethoxyl Groups," *Berichte der Deutschen Chemischen Gesellschaft,* Vol. 63, p. 2818 (1930).

(5) Q. P. Peniston and H. Hibbert, "The Determination of Methoxyl Groups in Pulp and Plant Materials," *Paper Trade Journal,* Vol. 109, No. 17, Oct. 26, 1939, p. 46.

(6) A. J. Bailey, "An Improved Methoxyl Apparatus," *Industrial and Engineering Chemistry,* Analytical Edition, Vol. 14, p. 181 (1942).

(7) E. P. Samsel and J. A. McHard, "Determination of Alkoxyl Groups in Cellulose Ethers," *Industrial and Engineering Chemistry,* Analytical Edition, Vol. 14, p. 750 (1942).

TECHNICAL ASSOCIATION OF PULP AND PAPER INDUSTRY
STANDARD METHOD T 6 m-54

Standard Method of Test for
ALCOHOL-BENZENE SOLUBILITY OF WOOD[1]

ASTM Designation: D 1107 – 56

Adopted, 1956.[2]

This Standard of the American Society for Testing Materials is issued under the fixed designation D 1107; the final number indicates the year of original adoption as standard or, in the case of revision, the year of last revision.

Scope

1. This method of test[3] is intended for determining the alcohol-benzene soluble content of wood, which is a measure of the waxes, fats, resins, and oils, plus tannins and certain other ether-insoluble components.

Apparatus

2. (*a*) *Filtering Crucibles.*—Alundum or fritted-glass filtering crucibles of coarse porosity shall be used.

(*b*) *Extraction Apparatus.*—A compact form of Soxhlet extraction apparatus, with ground-glass joints, is preferable. The apparatus shall consist of the following items:

(*1*) *Soxhlet Extraction Flask* having a capacity of 250-ml.

(*2*) *Soxhlet Extraction Tube,* 45 to 50 mm. in inside diameter, having a capacity to the top of the siphon of approximately 100 ml. and a siphon tube approximately 55 mm. in height. Extraction tubes of these dimensions siphon more rapidly than extractors with higher siphon tubes.

(*3*) *Condenser* of the Hopkins inner-cooled type.

Reagent

3. *Alcohol-Benzene Solution.*—Mix one volume of ethyl alcohol (95 per cent) and two volumes of c.p. benzene.

Test Specimen

4. The test specimen shall consist of 2 g. of air-dried sawdust that has been ground to pass a No. 40 (420-micron) sieve and be retained on a No. 60 (250-micron) sieve.

Procedure

5. (*a*) Weigh two 2-g. test specimens in tared alundum or fritted-glass crucibles. Dry one specimen in an oven for 2 hr. at 100 to 105 C.; then place in a loosely stoppered weighing bottle, cool in a desiccator, and weigh. Continue the drying for 1-hr. periods until the weight

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[1] Under the standardization procedure of the Society, this method is under the jurisdiction of the ASTM Committee D-7 on Wood.

[2] Prior to adoption as standard, this method was published as tentative from 1950 to 1956.

[3] For further information on this method the following reference may be consulted:

M. W. Bray, "Methods Used at the Forest Products Laboratory for the Chemical Analysis of Pulps and Pulpwoods," *Paper Trade Journal,* Vol. 87, No. 25, December 20, 1928, pp. 59–68.

is constant. Calculate the proportion of moisture-free sawdust in the air-dry specimen.

(*b*) Place the other specimen in a Soxhlet extraction apparatus having a tared Soxhlet extraction flask. Set a small cone of fine-mesh screen wire in the top of the crucible to prevent loss of specimen. Extract with 150 ml. of alcohol-benzene solution for 6 to 8 hr., keeping the liquid boiling briskly. This should provide four to six siphonings per hour.

(*c*) After evaporating the solvent from the extraction flask, dry the flask and contents in an oven for 1 hr. at 100 to 105 C., cool in a desiccator, and weigh. Continue the drying until there is no further loss in weight.

Calculation and Report

6. (*a*) Report the results as percentage by weight of alcohol-benzene soluble matter in the moisture-free wood, calculated as follows:

$$\text{Alcohol - benzene soluble matter, per cent} = \frac{W_2}{W_1 P} \times 100$$

where:

W_2 = weight of dried extract (Section 5 (*c*)),

W_1 = weight of test specimen used in Section 5 (*b*), and

P = proportion of moisture-free wood in the air-dry specimen (Section (*a*)).

(*b*) The results shall be based on the average of at least two determinations.

Standard Method of Test for
ETHER SOLUBILITY OF WOOD[1]

ASTM Designation: D 1108 – 56

Adopted, 1956.[2]

This Standard of the American Society for Testing Materials is issued under the fixed designation D 1108; the final number indicates the year of original adoption as standard or, in the case of revision, the year of last revision.

Scope

1. This method[3] is intended for determining the ether soluble content of wood, which is a measure of the waxes, fats, resins, oils, and similar materials.

Apparatus

2. (*a*) *Filtering Crucibles.*—Alundum or fritted-glass filtering crucibles of coarse porosity shall be used.

(*b*) *Extraction Apparatus.*—A compact form of Soxhlet extraction apparatus, with ground-glass joints, is preferable. The apparatus shall consist of the following items:

(*1*) *Soxhlet Extraction Flask* having a capacity of 250-ml.

(*2*) *Soxhlet Extraction Tube,* 45 to 50 mm. in inside diameter, having a capacity to the top of the siphon of approximately 100 ml. and a siphon tube approximately 55 mm. in height. Extraction tubes of these dimensions siphon more rapidly than extractors with higher siphon tubes.

(*3*) *Condenser* of the Hopkins inner-cooled type.

Reagent

3. *Ethyl Ether,* U.S.P.

Test Specimen

4. The test specimen shall consist of 2 g. of air-dried sawdust that has been ground to pass a No. 40 (420-micron) and be retained on a No. 60 (250-micron) sieve.

Procedure

5. (*a*) Weigh two 2-g. test specimens in tared alundum or fritted-glass crucibles. Dry one specimen in an oven for 2 hr. at 100 to 105 C.; then place in a loosely stoppered weighing bottle, cool in a desiccator, and weigh. Continue the drying for 1-hr. periods until the weight is constant. Calculate the proportion of moisture-free sawdust in the air-dry specimen.

(*b*) Place the other specimen in a Soxhlet extraction apparatus having a tared Soxhlet extraction flask. Set a small cone of fine-mesh screen wire in the top of the crucible to prevent loss of sample. Extract with 150 ml. of ethyl ether for 6 to 8 hr., keeping the ether boiling briskly. This should provide at least six to eight siphonings per hour.

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[1] Under the standardization procedure of the Society, this method is under the jurisdiction of the ASTM Committee D-7 on Wood.

[2] Prior to adoption as standard, this method was published as tentative from 1950 to 1956.

[3] For further information on this method the following reference may be consulted:
M. W. Bray, "Methods Used at the Forest Products Laboratory for the Chemical Analysis of Pulps and Pulpwoods," *Paper Trade Journal,* Vol. 87, No. 25, December 20, 1928, pp. 59–68.

(*c*) After evaporating the ether from the extraction flask, dry the flask and contents in an oven for 1 hr. at 100 to 105 C., cool in a desiccator, and weigh. Continue the drying until there is no further loss in weight.

Calculation and Report

6. (*a*) Report the results as percentage by weight of ether soluble matter in the moisture-free wood, calculated as follows:

$$\text{Ether soluble matter, per cent} = \frac{W_2}{W_1 P} \times 100$$

where:

W_2 = weight of dried extract (Section 5 (*c*)),

W_1 = weight of test specimen used in Section 5 (*b*), and

P = proportion of moisture-free sawdust in the air-dry specimen (Section 5 (*a*)).

(*b*) The results shall be based on the average of at least two determinations.

TECHNICAL ASSOCIATION OF PULP AND PAPER INDUSTRY
STANDARD METHOD T 4 m-54

Standard Method of Test for
ONE PER CENT CAUSTIC SODA SOLUBILITY OF WOOD[1]

ASTM Designation: D 1109 – 56

Adopted, 1956.[2]

This Standard of the American Society for Testing Materials is issued under the fixed designation D 1109; the final number indicates the year of original adoption as standard or, in the case of revision, the year of last revision.

Scope

1. This method is intended for determining the solubility of wood in a hot dilute alkali solution. A one per cent solution of caustic soda (NaOH) is used. One application is in determining the degree of fungus decay that has taken place in a given wood sample. As the wood decays, the percentage of alkali-soluble material increases in proportion to the decrease in pulp yield caused by the decay.

Apparatus

2. (*a*) *Water Bath.*—The water bath shall be designed so that the temperature of the material during treatment is uniformly maintained at 97 to 100 C. When a new bath is used the temperature shall be checked to ensure the use of proper conditions. The type of bath recommended is one that is covered and that has holes in the top of such size that beakers may be set down in the bath until they are supported by the flared rim of the beakers. The top of the beaker shall be nearly level with the cover of the bath. By using this type of bath the sides of the beakers are entirely surrounded by boiling water or steam. The water level in the bath shall be maintained above the level of the liquid in the beakers.

(*b*) *Beakers.*—The beakers shall be tall-form, 200-ml., alkali-resistant glass[3] beakers.

(*c*) *Filtering Crucibles.*—Alundum or fritted-glass crucibles of medium porosity are recommended for filtering the treated sawdust.

Reagents

3. (*a*) *Sodium Hydroxide Solution (1.0 per cent).*—Allow a c.p. NaOH solution (50 per cent) to stand about 1 week in a stoppered vessel to permit settling of Na_2CO_3 and other insoluble impurities. Dilute the supernatant clear solution with distilled water free of CO_2 and adjust to between 0.9 and 1.1 per cent NaOH.

(*b*) *Acetic Acid (10 per cent).*

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[1] Under the standardization procedure of the Society, this method is under the jurisdiction of the ASTM Committee D-7 on Wood.

[2] Prior to adoption as standard, this method was published as tentative from 1950 to 1956.

[3] Pyrex glass has been found satisfactory for this purpose.

Test Specimen

4. The test specimen shall consist of air-dried sawdust that has been ground to pass a No. 40 (420-micron) sieve and be retained on a No. 60 (250-micron) sieve. The weight of the test specimen shall be such that it will be equivalent to 2 ± 0.1 g. of moisture-free wood.

Procedure

5. (*a*) Place two test specimens in 200-ml., tall-form beakers and add to each 100 ml. of NaOH solution (1 per cent) measured carefully with a graduate. After stirring well, place the covered beakers in the water bath, which shall be boiling steadily. Leave the beakers in the bath for exactly 1 hr., stirring the contents three times, at periods of 10, 15, and 25 min. after the beakers are placed in the bath.

(*b*) At the end of 1 hr., filter the contents of each beaker by suction on a tared crucible. Wash the sawdust with 100 ml. of hot water, then with 50 ml. of acetic acid (10 per cent), and then thoroughly with hot water. Dry the crucible and contents to constant weight at 100 to 105 C., cool in a desiccator, and weigh in a stoppered weighing bottle.

Calculation and Report

6. (*a*) Report the results as percentage by weight of matter soluble in 1 per cent caustic soda solution, on the moisture-free basis, calculated as follows:

Matter soluble in caustic soda, per cent

$$= \frac{W_1 - W_2}{W_1} \times 100$$

where:

W_1 = weight of moisture-free wood in specimen prior to test (Section 4), and

W_2 = weight of dried specimen after treatment with the NaOH solution (Section 5 (*b*)).

(*b*) The results shall be based on the average of at least two determinations.

Standard Methods of Test for
WATER SOLUBILITY OF WOOD[1]

ASTM Designation: D 1110 – 56

Adopted, 1956.[2]

This Standard of the American Society for Testing Materials is issued under the fixed designation D 1110; the final number indicates the year of original adoption as standard or, in the case of revision, the year of last revision.

Scope

1. These methods[3] are intended for determining the water solubility of wood. Two methods are given, as follows:

Method A. Cold Water Solubility.—This method provides a measure of the tannins, gums, sugars, and coloring matter in the wood.

Method B. Hot Water Solubility.—This method provides a measure of the tannins, gums, sugars, coloring matter, *and starches* in the wood.

Method A. Cold-Water Solubility

Apparatus

2. (*a*) *Filtering Crucibles.*—Alundum or fritted-glass crucibles of coarse porosity will be required.

(*b*) *Filtering Flask.*—A suction filtering flask, equipped with a rubber flange for the crucible and funnel, shall be provided.

Test Specimen

3. The test specimen shall consist of 2 g. of air-dried sawdust that has been ground to pass a No. 40 (420-micron) sieve and be retained on a No. 60 (250-micron) sieve.

Procedure

4. (*a*) Place a 2-g. test specimen, the moisture content of which has been previously determined, in a 400-ml. beaker, and cover with 300 ml. of distilled water. Let this mixture digest at a temperature of 23 ± 2 C., with frequent stirring, for 48 hr.

(*b*) Filter the material on an alundum or fritted-glass crucible, using suction, wash with cold distilled water, and dry to constant weight at 100 to 105 C. Drying usually requires approximately 4 hr. Place the crucible in a loosely stoppered weighing bottle, cool in a desiccator, and weigh.

Report

5. Report the results as percentage of matter soluble in cold water, on the moisture-free basis, calculated as follows:

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[1] Under the standardization procedure of the Society, these methods are under the jurisdiction of the A.S.T.M. Committee D-7 on Wood.

[2] Prior to adoption as standard, these methods were published as tentative from 1950 to 1956.

[3] For further information on these methods the following references may be consulted:

A. W. Schorger, "Chemistry of Cellulose and Woods," p. 506, McGraw-Hill, New York (1926).

Hawley and Wise, "Chemistry of Wood," p. 134, Chemical Catalog Co., New York (1926).

M. W. Bray, "Methods Used at the Forest Products Laboratory for the Chemical Analysis of Pulps and Pulpwoods," *Paper Trade Journal*, Vol. 87, No. 25, December 20, 1928, pp. 59–68.

Cold water solubility, per cent

$$= \frac{W_1 - W_2}{W_1} \times 100$$

where:

W_1 = weight of moisture-free specimen used in Section 4 (*a*), and
W_2 = weight of dried specimen after extraction with cold water (Section 4 (*b*)).

METHOD B. HOT-WATER SOLUBILITY

Apparatus

6. (*a*) *Digestion Apparatus.*—A 200-ml. Erlenmeyer flask provided with a reflux condenser shall be used.

(*b*) *Water Bath.*—The water bath shall be so constructed that the water can be maintained at boiling temperature and at a constant-level just above the solution in the flask.

(*c*) *Filtering Crucible and Filtering Flask.*—See Section 2.

Test Specimen

7. See Section 3.

Procedure

8. (*a*) Place a 2-g. test specimen, the moisture content of which has been previously determined, and 100 ml. of distilled water in the Erlenmeyer flask and attach the reflux condenser. Place the flask in the boiling water bath, with the solution in the flask just below the level of the water in the bath, and heat gently for 3 hr.

(*b*) Filter the contents of the flask on a tared alundum or fritted-glass crucible, using suction, wash with hot water, and dry to constant weight at 100 to 105 C. Place the crucible in a loosely stoppered weighing bottle, cool in a desiccator, and weigh.

Report

9. Report the results as percentage of matter soluble in hot water, on the moisture-free basis, calculated as follows:

Hot water solubility, per cent

$$= \frac{W_1 - W_2}{W_1} \times 100$$

where:

W_1 = weight of moisture-free specimen used in Section 8 (*a*), and
W_2 = weight of dried specimen after extraction with hot water (Section 8 (*b*).

APPROVED AS
AMERICAN STANDARD
BY THE AMERICAN STANDARDS ASSOCIATION
ASA NO.: O4.5-1958
UDC 691.11:001.4

Standard Definitions of

TERMS RELATING TO TIMBER[1]

ASTM Designation: D 9 – 30

Adopted, 1907; Revised, 1915, 1930.

Reapproved in 1958 Without Change.

This Standard of the American Society for Testing Materials is issued under the fixed designation D 9; the final number indicates the year of original adoption as standard or, in the case of revision, the year of last revision.

The "Standard Names for Structural Timbers," which formerly were a part of these Definitions D 9, have been replaced by the Nomenclature of Domestic Hardwoods and Softwoods (ASTM Designation: D 1165).[2]

Structural Timber.—By the term "Structural Timber" is understood such products of wood in which the strength of the timber is the controlling element in its selection and use, such as trestle timbers (stringers, caps, posts, mud sills, bracing, bridge ties, guard rails); car timbers (car framing, including upper framing, car sills); framing for buildings (posts, mud sills, girders, framing joists); ship timbers (ship timbers, ship decking); and cross arms for poles.

Terms Relating to Wood

Annual Ring.[3]—In the case of wood, the growth layer put on in a single growth year.

Note.—It is usually dark in color. In trees like white spruce, hemlock, white fir,

Heartwood.[3]—The inner, dead portion of the wood in a tree.

basswood, and holly, the heartwood is not distinctly darker than the sapwood, and the two can not be readily distinguished.

Sapwood.[3]—The outer, live portion of the wood in a tree.

Note.—It is usually light in color.

Springwood.[3]—The softer, more porous portion of each annual ring.

Summerwood.[3]—The harder, less porous portion of each annual ring.

Note.—In softwoods it is darker than the springwood, but not always so in hardwoods. If the annual rings are fairly uniform in texture, as in maple, red gum, and yellow poplar, no distinction can be made between springwood and summerwood.

Pith.[3]—In the case of wood, the small soft core occurring in the structural center.

Sound Wood.—Wood free from any form of decay, incipient or advanced.

Standard Defects

Methods of measurement of size of knots or holes in the use-classifications of joist and plank, beams and stringers, and posts and timbers, are given in the Methods for Establishing Structural Grades of Lumber (ASTM Designation: D 245).[2]

Defect.[3]—In the case of wood, any irregularity occurring in or on the wood that may lower its strength.

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[1] Under the standardization procedure of the Society, these definitions are under the jurisdiction of the ASTM Committee D-7 on Wood.

[2] Appears in this publication, see Contents in Numeric Sequence of ASTM Designations at front of book.

[3] Revisions of the definitions of these terms appear in the Definitions of Terms Relating to Veneer and Plywood (ASTM Designation: D 1038), see p. 169.

Blemish.[3]—In the case of wood, anything, not necessarily a defect, marring its appearance.

Bark Pocket.[3]—Bark partially or wholly enclosed in wood.

Check.[3]—In the case of wood, a separation along the grain, the greater part of which occurs across the rings of annual growth.

End Check.—A check occurring at an end of a piece.

Heart Check.—A check starting near the pith and extending toward but not to the surface of a piece.

NOTE.—Several of these occurring together are called a star check.

Surface Check.—A check occurring at the surface of a piece.

Through Check.—A check extending through the piece from one surface to an opposite or to an adjoining surface.

Collapse.—In the case of wood, a caving at a surface of a piece.

NOTE.—It sometimes occurs in streaks, giving the surface a corrugated appearance and often is due to the flattening of the cells when wet wood is dried quickly.

Honeycombing.—In the case of wood, checks that occur in the interior of a piece, often not visible at the surface.

NOTE.—On a cross-section they usually appear as slits or pockets the width of which may be very large relative to the radial length.

Cross Break.[3]—A separation of the wood cells across the grain.

NOTE.—Such breaks may be due to internal strains resulting from unequal shrinkage or to external forces.

Cross-Grained Wood.[3]—Wood in which the fibers are not parallel with the axis of a piece.

Curly-Grained Wood.—Wood in which the fibers are distorted so that they afford a curled appearance, as in "bird's eye" wood.

NOTE.—Areas showing curly grain may vary up to several inches in diameter.

Diagonal-Grained Wood.[3]—Wood in which the fibers are at an angle with (that is, diagonal to) the axis of a piece as a result of sawing at an angle with the axis of the tree.

NOTE.—It may appear on either the radial or flat-grain surface.

Dip-Grained Wood.—Wood which has single waves or undulations of the fibers, such as occur around knots and pitch pockets.

Interlocked-Grained Wood.[3]—Wood in which the fibers are inclined in one direction in a number of rings of annual growth, then gradually reverse and are inclined in an opposite direction in succeeding growth rings, then later again reverse, etc.

Spiral-Grained Wood.[3]—Wood in which the fibers take a more or less winding or spiral course, as in a twisted tree.

NOTE.—It may be detected on the flat-grain surface.

Wavy-Grained Wood.[3]—Wood in which the fibers collectively take the form of waves or undulations.

NOTE.—It may appear on either the radial or flat-grain surface and is indicated by the wavy surface of a split piece.

Decay.[3]—In the case of wood, destruction of the wood substance due to the action of wood-destroying fungi.

NOTE.—"Dote" and "rot" are synonymous with "decay" and are any form of decay which may be evident either as a dark red discoloration, not found in the sound wood, or the presence of white or red rotten spots.

Advanced (or Typical) Decay.—In the case of wood, the older stage of decay in which the destruction is readily recognized because the wood has become punky, soft and spongy, stringy, ringshaked, pitted, or crumbly.

NOTE.—Decided discoloration or bleaching of the rotted wood is often apparent as, for example, brown and white rots, pocket rots.

Incipient Decay.—In the case of wood, the early stage of decay which has not proceeded far enough to soften or otherwise perceptibly impair the hardness of the wood.

NOTE.—It is usually accompanied by a slight discoloration or bleaching of the wood as instanced by the "firm red heart" in softwoods and the "water-soak" stage in certain types of decay.

Firm Red Heart.—A stage of incipient decay in wood characterized by a reddish color produced in the heartwood, which does not, however, make the wood unfit for the majority of yard purposes.

NOTE.—It is caused by the fungus *Trametes pini* and occurs chiefly in the pines.

Water-Soak (or Stain).—A term applied to a generally water-soaked area in heartwood, which is usually interpreted as the incipient stage of certain wood decays.

NOTE.—It occurs in hemlock and possibly in other woods.

Knot.[3,4] —In the case of wood, that portion of a branch which has become incorporated in the body of a tree.

Pin Knot.—A knot not over ½ in. in diameter.

Small Knot.—A knot over ½ in., but not over ¾ in., in diameter.

Medium Knot.—A knot over ¾ in., but not over 1½ in., in diameter.

Large Knot.—A knot more than 1½ in. in diameter.

Encased Knot.—A knot whose rings of annual growth are not intergrown and homogeneous with those of the surrounding wood.

NOTE.—The encasement may be partial or complete; if intergrown partially or so fixed by growth or position that it will retain its place in the piece, it shall be considered a tight knot; if completely intergrown on one face, it is a watertight knot.

Intergrown Knot.—A knot whose rings of annual growth are completely intergrown with those of the surrounding wood.

Loose Knot.—A knot not firmly held in place by growth or position.

Tight Knot.—A knot so fixed by growth or position that it will firmly retain its place in the piece.

Pith Knot.—A sound knot with a pith hole not more than ¼ in. in diameter in the center.

Round Knot.—A knot whose sawn section is oval or circular.

Spike Knot.—A knot sawn in a lengthwise direction.

Decayed Knot.—A knot which due to advanced decay is not as hard as the surrounding wood.

Sound Knot.—A knot which is solid across its face and which is as hard as the surrounding wood.

NOTE.—Red or black knots may be sound.

Pitch Pocket.[3]—An opening between the grain of the wood, containing more or less pitch.

NOTE.—Pitch pockets are classified as small, medium, and large.

Small Pitch Pocket.—A pocket not over ⅛ in. in width or not over 4 in. in length, or not over ¼ in. in width and not over 2 in. in length.

Medium Pitch Pocket.—A pocket not over ⅜ in. in width and 4 in. in length, or not over ⅛ in. in width and not over 8 in. in length.

Large Pitch Pocket.—A pocket over ⅜ in. in width and over 4 in. in length, or over ⅛ in. in width and over 8 in. in length.

Pitch Streak.[3]—A well-defined accumulation of pitch at one point in the piece.

NOTE.—When not sufficient to develop a well-defined streak, or where the fiber between grains, that is, the coarse-grained fiber, usually termed "springwood," is not saturated with pitch, it is not considered a defect.

Shake.[3]—In the case of wood, a separation along the grain, the greater part of which occurs between the rings of annual growth.

Through Shake.—A shake which extends between any two faces of a timber.

Wane.—Bark or lack of wood from any cause on edges of timbers.

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[4] Information covering the interpretation of knot measurement is given in the Appendix, see p. 167.

APPENDIX[5]

THE SIZE OF A KNOT

(Supplementing Definition of a Knot)

The ASTM standards for timber give very definite knot sizes that are to be permitted in any given grade and size of timber and a very concise and accurate definition of a knot. But it is not always easy to trace the outline of the knot on the surface of a timber and segregate the knot from the cross grain around the knot, which is a part of the body of the tree.

Sometimes there is a difference in color between the end grain of the limb wood and the surrounding wood. Sometimes there is a marked change in color that merely marks the heartwood of a live knot, and the sapwood of the knot may have the same color as the surrounding wood.

Again, we find knots in which there is practically no difference in color. The body of the tree is usually enlarged at a knot so that, when a knot is sawed through, the ring growth of the body wood looks very much like a part of the knot. How then are knot sizes to be determined?

There are two ways of determining the limits of a live knot when color or general appearance does not clearly demonstrate the boundary of the knot:

First.—The rings on the top of a limb are usually narrower than those on the bottom; and on a tangentially cut surface these rings at the top are narrower than those showing immediately above the knot in the body of the tree; also the rings in the body of the tree get wider as you measure away from the knot. The growth ring at the top of the knot can be traced around the knot to outline the size of the knot. When the knot is cut at an angle there will, as a rule, still be a place to one side of the top where the relatively narrow ring growth of the knot is suddenly changed to the wider growth rings of the tree trunk (see A, Fig. 1). On the side of the knot opposite these narrow growth rings, the growth rings will usually be found to get wider all the way from the pith center out

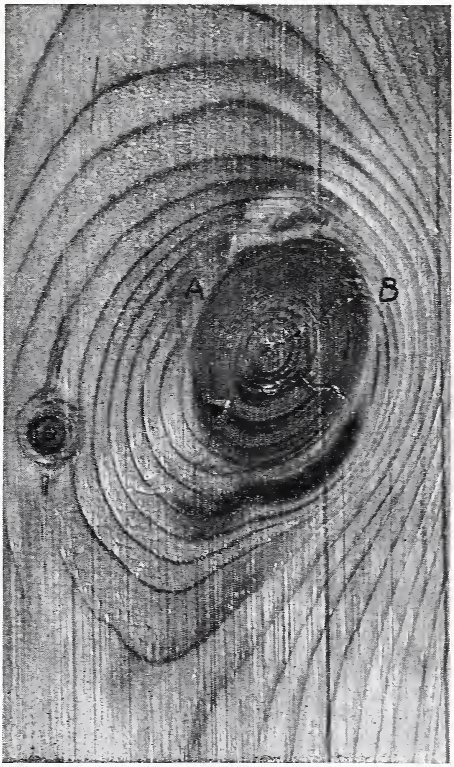

FIG. 1.

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[5] Prepared by John A. Newlin, Specialist in the Mechanics of Wood, Forest Products Laboratory, Forest Service, U. S. Department of Agriculture, maintained at Madison, Wis., in cooperation with the University of Wisconsin.

and it is often very difficult to establish the limit of the knots on that side except by tracing the growth rings from the other side of the knot.

Second.—Checks on the face of a knot run radially from the pith center and those running to the sides never run beyond the knot without an abrupt change in direction.

To one trying to determine the size of a knot, the oaks give a great deal of trouble due to two principal causes: First, color cannot be depended upon to outline the knot, and second, the body of the oak tree is usually greatly enlarged at a limb and a large amount of irregular or burly growth is introduced by a cut through the knot.

On the top of the oak knot it will usually be found that the very definite growth rings of the knot change very abruptly to burly irregular grain (see A, Fig. 2), often with bark pockets (see A, Fig. 3). This is the body wood above the knot. The radial checking in the oak knot is often very prominent and can be used to determine the limits of the knot. The checks follow the rays and run approximately radially from the pith center of the knots. The checks running to the bottom of the knot may run approximately straight far beyond the limit of the knot and occasionally those running to the top may run through the burly wood above the knot in more or less of a straight line, but the checks running to the sides of the knot, while they may stop short of the limit of the knot, never run without an abrupt change of direction beyond the limit of the knot (see B, Figs. 1 and 2).

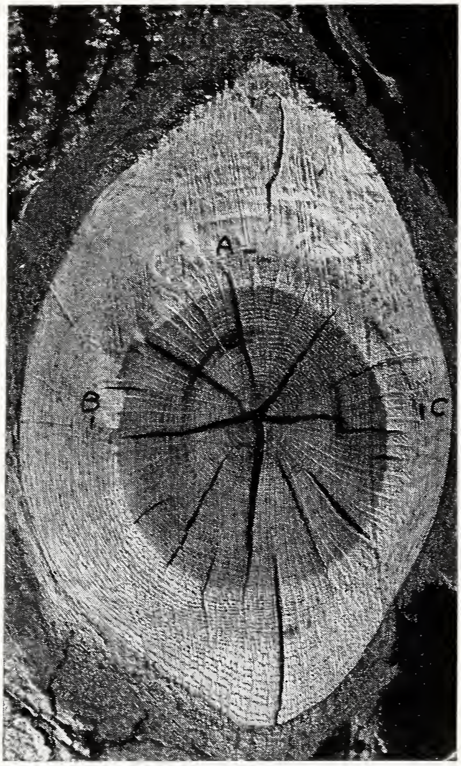

FIG. 2.

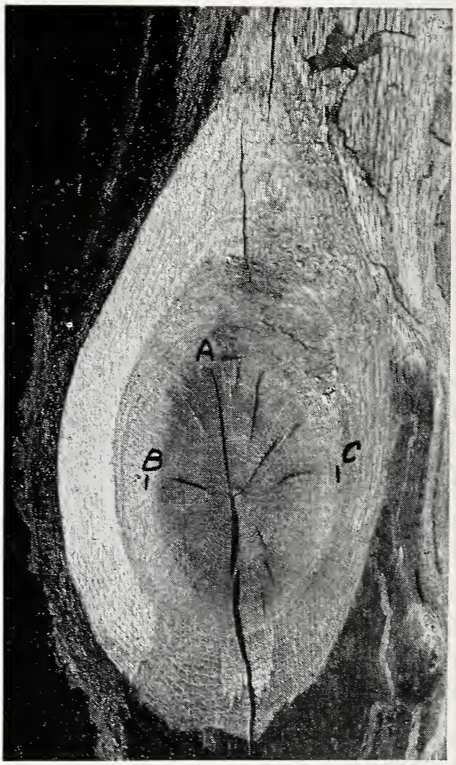

FIG. 3.

APPROVED AS
AMERICAN STANDARD
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UDC 674.243:001.4

Standard Definitions of
TERMS RELATING TO VENEER AND PLYWOOD[1]

ASTM Designation: D 1038 – 52

Adopted, 1952.[2]

Reapproved in 1958 Without Change.

This Standard of the American Society for Testing Materials is issued under the fixed designation D 1038; the final number indicates the year of original adoption as standard or, in the case of revision, the year of last revision.

Adhesive.—A substance capable of holding materials together by surface attachment. It is a general term and includes cements, mucilage, and paste, as well as glue.

Annual Growth Rings.—See Ring, Annual.

Back.—The side reverse to the face of a panel, or the poorer side of a panel in any grade of plywood calling for a face and back.

Balanced Construction.—See Construction, Balanced

Banding (Railing).—A portion of wood of any specified kind extending around one or more sides of a piece of core, usually with its grain parallel to the edge of the panel. This banding of solid wood facilitates shaping of the edges of the piece or it may be finished flat to cover the several colors presented in the end or side grain of the core.

Bark Pocket.[3]—An opening between annual growth layers that contains bark. Bark pockets appear as dark streaks on radial surfaces and as rounded areas on tangential surfaces.

Birdseye.—Small localized areas in wood with the fibers indented and otherwise contorted to form few to many small circular or elliptical figures remotely resembling birds' eyes on the tangential surface. Common in sugar maple and used for decorative purposes, rare in other hardwood species; not a defect if sound.

Bleed Through.—Glue or components of glue that have seeped through the outer layer or ply of a glued wood product and that show as a blemish or discoloration on the surface.

Blemish.[3]—Anything marring the appearance of the veneer that is not classifiable as a defect.

Blister.—An elevation of the surface of an adherend, somewhat resembling in shape a blister on the human skin; its boundaries may be indefinitely outlined and it may have burst or become flattened.

Bolt (Veneer).—A short log cut to length suitable for peeling in a lathe.

Bond, *n.*—The attachment at an interface between an adhesive and an adherend.

Bond, *v.*—To attach materials together by means of an adhesive.

Brashness.—A condition that causes some pieces of wood to be relatively low in shock resistance for the species and, when broken in flexure, to fail abruptly without splintering at comparatively small deflections.

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[1] Under the standardization procedure of the Society, these definitions are under the jurisdiction of the A.S.T.M. Committee D-7 on Wood.

[2] Prior to adoption as standard, these definitions were published as tentative from 1949 to 1952.

[3] These definitions represent a revision of the corresponding terms in the Standard Definitions of Terms Relating to Timber (A.S.T.M. Designation: D 9), see p. 164.

Burl.—(*1*) A hard woody excresence on a tree, more or less rounded in form, usually resulting from the entwined growth of a cluster of adventitious buds. Such burls are the source of the highly figured burl veneers used for purely ornamental purposes.

(*2*) In veneer, a localized severe distortion of the grain generally rounded in outline, usually resulting from overgrowth of dead branch stubs, varying from $\frac{1}{2}$ in. to several inches in diameter; frequently includes one or clusters of several small contiguous conical protuberances, each usually having a core or pith but no appreciable amount of end grain (in tangential view) surrounding it.

Caul (Gluing).—Boards, panels, or metal sheets that are used in gluing operations to provide uniform distribution of the gluing pressure; or used to prevent precure of glue by slowing up transfer of heat to plywood having thin face veneers.

Center.—See Core.

Check.[3]—A lengthwise separation of the wood which usually extends across the rings of annual growth, commonly resulting from the stresses set up in wood during seasoning.

Clipper.—The shearing machine used to dimension dry or green veneers.

Compregnated Wood (Compreg).—Synthetic resin-treated, compressed wood with reduced swelling and shrinking characteristics and increased density and strength properties.

Compression Failure.—Deformations of the fibers due to excessive compression along the grain either in direct end compression or in bending. It may develop in standing trees due to bending by wind or snow or to internal longitudinal stresses due to growth, or it may result from imposed stresses after the tree is cut.

Compression Wood.—Abnormal wood formed on the lower side of branches and inclined trunks of softwood trees. Compression wood is identified by its relatively wide annual rings, usually eccentric, its relatively large amount of summerwood, sometimes more than 50 per cent of the width of annual rings in which it occurs and a lack of demarkation between springwood and summerwood in the same annual ring. Compression wood shrinks excessively lengthwise as compared with normal wood.

Construction.—Arrangement of veneers or lumber in the fabrication of plywood.

All-Veneer Construction.—Plywood in which all plies are of veneer. Ordinarily no single ply of veneer will exceed $\frac{5}{16}$ in. in thickness.

Balanced Construction.—A construction such that the forces induced by uniformly distributed changes in moisture content will not cause warpage. Symmetrical constructions in which the grain directions of the plies are either parallel or perpendicular to each other are balanced constructions.

Lumber Core Construction.—Plywood in which the center ply or core is of lumber rather than of veneer. Ordinarily cores that are $\frac{3}{8}$ in. or greater in thickness will be of lumber.

Symmetrical Construction. — Plywood panels in which the plies on one side of a center ply or core are essentially equal in thickness, grain direction, properties, and arrangement to those on the other side of the core.

Core.—(*1*) The center ply in a plywood panel. It may be of lumber either one piece or several pieces, edge-glued together or of one or more thicknesses of veneer.

(*2*) In cutting rotary veneer, the portion of the bolt remaining after available veneer has been cut, also referred to as core blocks.

Cross Band, *n.*—The layers of veneer whose grain direction is at right angles to that of the face plies, applied particularly to five-ply plywood and lumber-core panels.

Cross Band, *v.*—To place the grain of the layers of veneer at right angles in order to minimize swelling and shrinking.

Cross Break.[3]—A separation of the wood cells across the grain. Such breaks may be due to internal stresses resulting from nonuniform longitudinal shrinkage or to external forces.

Decay.[3]—The decomposition of wood substance by fungi.

Defect.[3]—Any irregularity occurring in or on veneer that may lower its strength.

Open Defect.—Any irregularity such as checks, splits, open joints, cracks, knot holes, or loose knots that interrupts the smooth continuity of the veneer.

Delamination.—Separation of the plies through failure of the adhesive; may be referred to as durability of the glue line.

Dote.[3]—"Dote," "Doze," and "Rot" are synonymous with "decay" and are any form of decay which may be evident as a discoloration or a softening of the wood.

Drier.—A kiln or chamber, or machine through which the green veneers are passed to remove excess moisture.

Durability.—As applied to wood, its lasting qualities or permanence in service with particular reference to decay. May be related directly to an exposure condition. (See also Delamination.)

Edge Joint.—See Joint.

Exterior.—A term frequently applied to plywood, bonded with highly resistant adhesives, that is capable of withstanding prolonged exposure to severe service conditions without failure in the glue bonds.

Face.—The better side of a panel in any grade of plywood calling for a face and back; also either side of a panel where the grading rules draw no distinction between faces.

Flitch.—A portion of a log sawed on two or more sides and intended for remanufacture into lumber or into sliced or sawed veneer. The term is also applied to the resulting sheets of veneer laid together in sequence of cutting.

Glue, *n.*—A substance capable of holding materials together by surface attachment. (In woodworking it often carries the concept implying a substance capable of forming a strong bond with wood.)

Glue, *v.*—To attach materials together by means of glue.

Glue Joint.—See Joint.

Grade.—The designation of the quality of plywood.

Grain.—The direction, size, arrangement, appearance, or quality of the fibers in wood or veneer. To have a specific meaning the term must be qualified.

Close Grain.—Produced by narrow and inconspicuous annual growth rings. The term is sometimes used to designate wood having small and closely spaced pores but in this sense the term "fine textured" is more often used.

Coarse Grain.—Produced by wide and conspicuous annual rings having considerable difference between springwood and summerwood. The term is sometimes used to designate wood with large pores, such as oak, ash, chestnut, and walnut but in this sense the term "coarse texture" is more often used.

Cross Grain.[3]—A pattern in which the fibers and other longitudinal elements deviate from a line parallel to the sides of the piece. Applies to either diagonal or spiral grain or a combination of the two.

Diagonal Grain.[3]—Grain in which the longitudinal elements form an angle with the axis of the piece as a result of sawing at an angle with the bark of the tree or log; a form of cross grain.

Edge Grain.—In wood or veneer so sawed that the annual rings form an angle of 45 to 90 deg. with the surface of the piece.

Flat Grain.—In wood or veneer so sawed that the annual rings form an angle of less than 45 deg. with the surface of the piece.

Interlocked Grain.[3]—Grain in which the fibers incline in one direction in a number of rings of annual growth, then gradually reverse and incline in an opposite direction in succeeding rings and then reverse again.

Open Grain.—Common classification for woods with large pores such as oak, ash, chestnut, and walnut. Also known as "coarse textured."

Spiral Grain.[3]—A form of cross grain in which the fibers extend spirally about instead of vertically along the bole of a tree or axis of a timber.

Vertical Grain.—Another term for edge grain.

Wavy Grain.[3]—Grain in which the fibers and other longitudinal elements collectively take the form of waves or undulations.

Hardwood.—Generally one of the botanical groups of trees that have broad leaves in contrast to the conifers. The term has no reference to the actual hardness of the wood.

Heartwood.[3]—The inner core of a woody stem wholly composed of nonliving cells and usually differentiated from the outer enveloping layer (sapwood) by its darker color. It is usually more decay resistant than sapwood.

Impreg.—Synthetic resin-treated wood made so as to reduce materially its swelling and shrinking.

Interior.—A term frequently applied to plywood bonded with adhesives that maintain adequate bonds under conditions usually existing in the interior of buildings in the United States.

Joint.—The junction of two adjacent pieces of wood or veneer.

Butt Joint.—The place where two pieces of wood are joined together end to end.

Edge Joint.—The place where two pieces of wood are joined together edge to edge.

Glue Joint.—The place where two pieces of wood are joined together by means of glue.

Open Joint.—Failure of bond or separation of two adjacent pieces of veneer so as to leave an opening, usually applied to edge joints between veneers.

Starved Joint.—A glue joint which is poorly bonded because of an insufficient quantity of glue.

Knot.[3]—That portion of a branch or limb that has been surrounded by subsequent growth of the wood of the trunk or other portion of the tree.

Decayed Knot.—A knot which, because of advanced decay, is softer than the surrounding wood.

Encased Knot.—A knot in which the growth layers are not intergrown with those of the surrounding wood.

Intergrown Knot.—A knot in which the growth layers are completely intergrown with those of the surrounding wood.

Loose Knot.—A knot which is not held firmly in place by growth or position and which cannot be relied upon to remain in place.

Pin Knot.—A knot which is not over $\frac{1}{2}$ in. in diameter.

Round Knot.—A knot which is cut so that the exposed section is oval or circular.

Small Knot.—A knot over $\frac{1}{2}$ in. but not more than $\frac{3}{4}$ in. in diameter.

Sound Knot.—A knot which is solid across its face, at least as hard as the surrounding wood, and shows no indication of decay.

Spike Knot.—A knot cut approximately parallel to its long axis so that the exposed section is definitely elongated.

Knotholes.—Voids produced by the dropping of knots from the wood in which they were originally embedded.

Lap.—A condition in which adjacent veneers are so misplaced that one piece overlaps the other instead of making a smooth edge joint.

Lathe.—The machine on which rotary and half-round veneer is cut.

Loose Side.—In knife-cut veneer, that side of the sheet that was in contact with the knife as the sheet was being cut, and containing cutting checks because of the bending of the wood at the knife edge. See *Tight Side.*

Matching.—The orientation of sheets of veneer to obtain a particular pattern.

Book Matching.—Turning alternate adjacent sheets of veneer of a flitch over.

Reversed Matching.—Turning alternate adjacent sheets of veneer of a flitch end for end; also called "swing matching."

Slip Matching.—Laying adjacent sheets of veneer tight side up without turning; also called "slide matching."

Mineral Streak.—An olive to greenish-black or brown discoloration of undetermined cause in hardwoods, particularly hard maples commonly associated with bird pecks and other injuries, occurring in streaks usually containing accumulations of mineral matter.

Moisture Content.—The amount of water contained in the wood, usually expressed as a percentage of the weight of the oven-dry wood.

Open Joint.—See Joint.

Open Grain.—See Grain.

Panel.—A sheet of plywood of any construction type.

Patches.—Insertions of sound wood, having tapered sides, placed and glued into veneers from which defective portions have been removed.

Peeler Log.—A log selected and suitable for cutting into rotary veneer.

Pitch Pocket.[3]—An opening extending parallel to the annual growth layers, usually containing or which has contained pitch, either solid or liquid.

Pitch Streak.[3]—A well defined accumulation of pitch in a more or less regular streak in the wood of certain conifers.

Pith.[3]—The small soft core occurring in the structural center of a log.

Platen.—A plate of metal, especially one that exerts or receives pressure, as in a press used for gluing plywood.

Plugs.—Straight-sided insertions of sound wood placed into veneers from which defective portions have been removed.

Ply.—A single sheet of veneer, or several sheets laid with adjoining edges, that may or may not be glued, which form one layer in a piece of plywood.

Plywood.—A cross-banded assembly made of layers of veneer or veneer in combination with a lumber core or plies joined with an adhesive. Two types of plywood are recognized, namely; (*1*) veneer plywood, and (*2*) lumber core plywood.

NOTE.—Generally the grain of one or more plies is approximately at right angles to the other plies and almost always an odd number of plies are used.

Press.—An apparatus for applying and maintaining pressure on an assembly of veneers and adhesive in the fabrication of plywood. It may be operated mechanically or hydraulically and the platens may be cold or heated depending on the type of adhesive used.

Railing.—See Banding.

Ring, Annual.[3]—The annual growth layer as viewed on a cross-section of a stem, branch, or root.

Rotary-Cut Veneer.—See Veneer.

Sapwood.[3]—The living wood of pale color near the outside of the log. Under most conditions the sapwood is more susceptible to decay than heartwood.

Sawed Veneer.—See Veneer.

Shake.[3]—A separation along the grain, the greater part of which occurs between the rings of annual growth.

Shim.—A long narrow patch not more than $\frac{3}{16}$ in. in width.

Sliced Veneer.—See Veneer.

Slicer.—Machine for producing veneer by slicing.

Softwoods.—Generally, one of the botanical groups of trees that in most cases have needle or scalelike leaves; the conifers; also the wood produced by such trees. The term has no reference to the actual hardness of the wood.

Specific Gravity.—The ratio of the weight of a body to the weight of an equal volume of water at 4 C. or other specified temperature.

Split.—A lengthwise separation of the wood due to the tearing apart of the wood cells.

Springwood.[3]—The portion of the annual growth ring that is formed during the early part of the seasons growth. It is usually less dense and weaker mechanically than summerwood.

Stain.—A discoloration in wood that may be caused by such diverse agencies as microorganisms, metal, or chemicals. The term also applies to materials used to impart color to wood.

Stay Log.—A device used on a veneer lathe to which is fastened a segment of the bolt or flitch to secure desired grain effects in the veneer.

Streak, Pitch.—See Pitch Streak.

Streak, Mineral.—See Mineral Streak.

Striated.—A term used to describe plywood with a face veneer that has been grooved or scored parallel to the grain.

Summerwood.[3]—The portion of the annual growth ring that is formed after the springwood formation has ceased. It is usually more dense and stronger mechanically than springwood.

Sunken Joint.—In the case of plywood, a depression in the surface of the face ply directly above an edge joint in a lumber core or cross band. Usually the result of localized shrinkage in the edge-jointed layer. (Sunken joints may also be present in edge-laminated lumber.)

Tape.—Ribbons, usually of paper or cloth, coated with adhesive that are used to fasten veneers together for convenience in handling during the gluing operation.

Texture.—A term often used interchangeably with grain. Sometimes used to combine the concepts of density and degree of contrast between springwood and summerwood. See *Grain.*

Tight Side.—In knife-cut veneer, that side of the sheet that was farthest from the knife as the sheet was being cut and containing no cutting checks. See *Loose Side.*

Type.—The designation of the moisture resistance of plywood.

Veneer.—A thin layer or sheet of wood.

Back.—Term usually applied to veneer used for concealed or unfinished side of plywood and veneered panels for furniture.

Face.—Term usually applied to veneer used for exposed or finished surfaces of plywood and veneered panels for furniture.

Figured.—Veneer containing irregular grain formations that add to its value for furniture panel faces and other decorative uses. Various figures are referred to as rift-cut, needle-point, comb-grained, stripe, rope, roe, mottle, fiddle-back, raindrop, finger roll, cross-fire, chain, curly, blister, birds' eye, feather, crotch, stump, burl, etc.

Half-Round.—A manner of cutting veneer to bring out a certain beauty of figure. The flitch is mounted on a stay log and is cut on a lathe. It differs from rotary-cut veneer in that the flitch is cut with a wider sweep than when mounted at the lathe center, and the center of the tree is not near the center of rotation.

Rotary-Cut Veneer.—Veneer cut in a continuous strip by rotating a log or bolt against a knife.

Sawed Veneer.—Veneer produced by sawing.

Sliced Veneer.—Veneer that is sliced off by moving a log, bolt, or flitch against a knife.

Waterproof.—As applied to plywood, the term is synonymous with Exterior; that is, plywood, bonded with highly resistant adhesives, which is capable of withstanding prolonged exposure to severe service conditions without failure in the glue bonds.

Water Resistant.—A term frequently applied to plywood, bonded with moderately resistant adhesives, which is capable of withstanding limited exposure to water or to severe conditions without failure in the glue bonds.

APPROVED AS
AMERICAN STANDARD
BY THE AMERICAN STANDARDS ASSOCIATION
ASA NO.: O4.6-1958
UDC 691.112/.113:001.4

Standard Nomenclature of
DOMESTIC HARDWOODS AND SOFTWOODS[1]

ASTM Designation: D 1165 – 52

ADOPTED, 1952.[2]

Reapproved in 1958 Without Change in Substance.

This Standard of the American Society for Testing Materials is issued under the fixed designation D 1165; the final number indicates the year of original adoption as standard or, in the case of revision, the year of last revision.

NOTE.—Editorial changes were made in October, 1958.

Commercial Names for Lumber[3]	Official Common Tree Names[4]	Botanical Names
	HARDWOODS	
Alder:		
Red Alder	red alder	*Alnus rubra*
Ash:		
Black Ash[5]	black ash	*Fraxinus nigra*
Oregon Ash	Oregon ash	*Fraxinus latifolia*
Pumpkin Ash	pumpkin ash	*Fraxinus profunda*
White Ash	blue ash	*Fraxinus quadrangulata*
	green ash	*F. pennsylvanica*
	white ash	*F. americana*
Aspen[6]	bigtooth aspen	*Populus grandidentata*
	quaking aspen	*P. tremuloides*
Basswood[7]	American basswood	*Tilia americana*
	white basswood	*T. heterophylla*
Beech	American beech	*Fagus grandifolia*
Birch[8]	gray birch	*Betula populifolia*
	paper birch	*B. papyrifera*
	river birch	*B. nigra*
	sweet birch	*B. lenta*
	yellow birch	*B. alleghaniensis*

Under the standardization procedure of the Society, this nomenclature is under the jurisdiction of the ASTM Committee D-7 on Wood.

[2] Prior to adoption as standard, this nomenclature was published as tentative from 1951 to 1952.

[3] The commercial names for lumber represent recommended commercial practice.

[4] The official common tree names conform to the *Check List of Native and Naturalized Trees of the United States* (including Alaska), Agriculture Handbook No. 41 (1953), and are sometimes used as names for lumber. In addition to the official common name for a species, the *Check List* also lists other names by which the species and the lumber produced from it are sometimes designated.

[5] Black ash is known commercially in some consuming centers as brown ash, and is also sometimes designated as such in specifications.

[6] Aspen lumber is sometimes designated as Popple.

[7] For some commercial uses where a white appearance is a requirement, the sapwood of American basswood (*Tilia americana*) is specified under the designation White Basswood. This commercial use designation should not be confused with the species (*Tilia heterophylla*) having the common name "White Basswood."

[8] Usually designated either as Red Birch or as Sap (White) Birch, as the case may be, or as Birch if unselected for color.

Commercial Names for Lumber[3]	Official Common Tree Names[4]	Botanical Names
	HARDWOODS—*Continued*	
Box Elder	boxelder	*Acer negundo*
Buckeye	Ohio buckeye	*Aesculus glabra*
	yellow buckeye	*A. octandra*
Butternut	butternut	*Juglans cinerea*
Cherry	black cherry	*Prunus serotina*
Chestnut	American chestnut	*Castanea dentata*
Cottonwood	balsam poplar	*Populus balsamifera*
	eastern cottonwood	*P. deltoides*
	plains cottonwood	*P. sargentii*
	swamp cottonwood	*P. heterophylla*
Cucumber	cucumbertree	*Magnolia acuminata*
Dogwood	flowering dogwood	*Cornus florida*
	Pacific dogwood	*C. nuttalli*
Elder: See Box Elder		
Elm:		
Rock Elm	cedar elm	*Ulmus crassifolia*
	rock elm	*U. thomasii*
	September elm	*U. serotina*
	winged elm	*U. alata*
Soft Elm[9]	American elm	*Ulmus americana*
	slippery elm	*U. rubra*
Gum[10]	sweetgum	*Liquidambar styraciflua*
Hackberry	hackberry	*Celtis occidentalis*
	sugarberry	*C. laevigata*
Hickory[11]	mockernut hickory	*Carya tomentosa*
	pignut hickory	*C. glabra*
	shagbark hickory	*C. ovata*
	shellbark hickory	*C. laciniosa*
Holly	American holly	*Ilex opaca*
Ironwood	eastern hophornbeam	*Ostrya virginiana*
Locust	black locust	*Robinia pseudoacacia*
	honeylocust	*Gleditsia triacanthos*
Madrone	Pacific madrone	*Arbutus menziesii*
Magnolia	southern magnolia	*Magnolia grandiflora*
	sweetbay	*M. virginiana*
Maple:		
Hard Maple[12]	black maple	*Acer nigrum*
	sugar maple	*A. saccharum*
Oregon Maple	bigleaf maple	*Acer macrophyllum*
Soft Maple[12]	red maple	*Acer rubrum*
	silver maple	*A. saccharinum*
Mulberry	red mulberry	*Morus rubra*
Myrtle: See Oregon Myrtle		

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[9] Soft Elm lumber is sometimes designated as White Elm.

[10] Usually designated either as Red Gum or as Sap Gum, as the case may be, or as Gum or Sweetgum if unselected for color. (For Black Gum, see footnote 14, for Tupelo.)

[11] The impossibility of distinguishing between Hickory lumber and Pecan lumber for accurate species identification in all cases is recognized.

[12] When Hard Maple or Soft Maple is specified to be white, the specification is interpreted as being a requirement for sapwood.

Commercial Names for Lumber[3]	Official Common Tree Names[4]	Botanical Names
	HARDWOODS—*Continued*	
Oak:		
Red Oak	black oak	*Quercus velutina*
	blackjack oak	*Q. marilandica*
	California black oak	*Q. kelloggii*
	cherrybark oak	*Q. falcata var. pagodaefolia*
	laurel oak	*Q. laurifolia*
	northern pin oak	*Q. ellipsoidalis*
	northern red oak	*Q. rubra*
	Nuttall oak	*Q. nuttallii*
	pin oak	*Q. palustris*
	scarlet oak	*Q. coccinea*
	Shumard oak	*Q. shumardii*
	southern red oak	*Q. falcata*
	turkey oak	*Q. laevis*
	willow oak	*Q. phellos*
White Oak	Arizona white oak	*Quercus arizonica*
	blue oak	*Q. douglasii*
	bur oak	*Q. macrocarpa*
	California white oak	*Q. lobata*
	chestnut oak	*Q. prinus*
	chinkapin oak	*Q. muehlenbergii*
	Emory oak	*Q. emoryi*
	Gambel oak	*Q. gambelii*
	Mexican blue oak	*Q. oblongifolia*
	live oak	*Q. virginiana*
	Oregon white oak	*Q. garryana*
	overcup oak	*Q. lyrata*
	post oak	*Q. stellata*
	swamp chestnut oak	*Q. michauxii*
	swamp white oak	*Q. bicolor*
	white oak	*Q. alba*
Oregon Myrtle	California-laurel	*Umbellularia californica*
Osage Orange[13]	Osage-orange	*Maclura pomifera*
Pecan[11]	bitternut hickory	*Carya cordiformis*
	nutmeg hickory	*C. myristicaeformis*
	water hickory	*C. aquatica*
	pecan	*C. illinoensis*
Persimmon	common persimmon	*Diospyros virginiana*
Poplar	yellow-poplar	*Liriodendron tulipifera*
Sassafras	sassafras	*Sassafras albidum*
Silverbell	Carolina silverbell	*Halesia carolina*
Sycamore	American sycamore	*Platanus occidentalis*
Tupelo[14]	black tupelo	*Nyssa sylvatica*
	Ogeechee tupelo	*N. ogeche*
	water tupelo	*N. aquatica*
Walnut	black walnut	*Juglans nigra*
Willow	black willow	*Salix nigra*
	peachleaf willow	*S. amygdaloides*

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[13] Osage Orange is sometimes designated either as bodarc or as bois d'arc.

[14] The impossibility of distinguishing between Black Tupelo (Black Gum) lumber and Water Tupelo lumber for accurate species identification in all cases is recognized.

Commercial Names for Lumber[3]	Official Common Tree Names[4]	Botanical Names
SOFTWOODS		
Cedar:		
Alaska Cedar	Alaska-cedar	*Chamaecyparis nootkatensis*
Incense Cedar	incense-cedar	*Libocedrus decurrens*
Port Orford Cedar	Port-Orford-cedar	*Chamaecyparis lawsoniana*
Eastern Red Cedar	eastern redcedar	*Juniperus virginiana*
	southern redcedar	*J. silicicola*
Western Red Cedar	western redcedar	*Thuja plicata*
Northern White Cedar	northern white-cedar	*Thuja occidentalis*
Southern White Cedar	Atlantic white-cedar	*Chamaecyparis thyoides*
Cypress[15]	baldcypress	*Taxodium distichum*
	pondcypress	*T. distichum var. nutans*
Fir:		
Balsam Fir[16]	balsam fir	*Abies balsamea*
	Fraser fir	*A. fraseri*
Douglas Fir[17]	Douglas-fir	*Pseudotsuga menziesii*
Noble Fir	noble fir	*Abies procera*
White Fir	subalpine fir	*Abies lasiocarpa*
	California red fir	*A. magnifica*
	grand fir	*A. grandis*
	noble fir	*A. procera*
	Pacific silver fir	*A. amabilis*
	white fir	*A. concolor*
Hemlock:		
Eastern Hemlock	Carolina hemlock	*Tsuga caroliniana*
	eastern hemlock	*T. canadensis*
Mountain Hemlock	mountain hemlock	*Tsuga mertensiana*
West Coast Hemlock	western hemlock	*Tsuga heterophylla*
Juniper:		
Western Juniper	alligator juniper	*Juniperus deppeana*
	Rocky Mountain juniper	*J. scopulorum*
	Utah juniper	*J. osteosperma*
	western juniper	*J. occidentalis*
Larch:		
Western Larch	western larch	*Larix occidentalis*
Pine:		
Jack Pine	jack pine	*Pinus banksiana*
Lodgepole Pine	lodgepole pine	*P. contorta*
Norway Pine	red pine	*P. resinosa*
Ponderosa Pine	ponderosa pine	*P. ponderosa*
Sugar Pine	sugar pine	*P. lambertiana*
Idaho White Pine	western white pine	*P. monticola*

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[15] Cypress includes types designated as Red Cypress, White Cypress, and Yellow Cypress. Red Cypress is frequently classified and sold separately from the other types.

[16] Balsam Fir lumber is sometimes designated either as Eastern Fir or as Balsam.

[17] Douglas Fir may be specified either as Coast Region Douglas Fir or as Inland Region Douglas Fir, but if the particular type is not so specified or is not otherwise indicated through the grade specifications, either or both types will be allowed.

Commercial Names for Lumber[3]	Official Common Tree Names[4]	Botanical Names
SOFTWOODS—*Continued*		
Northern White Pine...	eastern white pine..........	*Pinus strobus*
Longleaf Yellow Pine[18]..	longleaf pine...............	*Pinus palustris*
	slash pine..................	*P. eliottii*
Southern Yellow Pine...	loblolly pine...............	*Pinus taeda*
	longleaf pine...............	*P. palustris*
	pitch pine..................	*P. rigida*
	shortleaf pine..............	*P. echinata*
	slash pine..................	*P. eliottii*
	Virginia pine...............	*P. virginiana*
Redwood................	redwood....................	*Sequoia sempervirens*
Spruce:		
Eastern Spruce.........	black spruce...............	*Picea mariana*
	red spruce.................	*P. rubens*
	white spruce...............	*P. glauca*
Engelmann Spruce......	blue spruce................	*Picea pungens*
	Engelmann spruce..........	*P. engelmannii*
Sitka Spruce...........	Sitka spruce...............	*Picea sitchensis*
Tamarack...............	tamarack..................	*Larix laricina*
Yew:		
Pacific Yew............	Pacific yew................	*Taxus brevifolia*

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[18] The commercial requirements for Longleaf Yellow Pine lumber are that not only must it be produced from trees of the botanical species of ***Pinus elliottii*** and ***Pinus palustris***, but each piece in addition must average either on one end or the other not less than six annual rings per inch and not less than one-third summerwood. Longleaf Yellow Pine lumber is sometimes designated as Pitch Pine in the export trade.

Tentative Definitions of

TERMS RELATING TO WOOD-BASE FIBER AND PARTICLE PANEL MATERIALS[1]

ASTM Designation: D 1554 – 58 T

Issued, 1958.[2]

These Tentative Definitions have been approved by the sponsoring committee and accepted by the Society in accordance with established procedures, for use pending adoption as standard. Suggestions for revisions should be addressed to the Society at 1916 Race St., Philadelphia 3, Pa.

Introduction

The terms included in these definitions are intended to apply to a family of ligno-cellulosic panel materials specially manufactured for use industrially as components (core, facing, or panels) of furniture, cabinets, and the like, and in building construction as siding, sheathing, partitions, door cores and paneling, acoustical treatments, and as structural components there and elsewhere where the combination of thickness, panel size, and properties satisfy a particular need. The usual alternate materials to these wood-base panel materials are wood in the form of lumber and plywood, plastics, inorganic fiber cement boards, and gypsum board.

The terms used and defined herein differ slightly from some practice. Modifications appeared to be desirable to clarify the nomenclature since confusion exists because of the similarity of some existing terms with those for other materials. The use of the terms herein will do much to standardize the terms pertaining to insulating board, hardboard, and particle board, the principal materials included. The board or panel materials included are those derived from wood and the woody tissue of such plants as bagasse, flax, and straw. They fall into two general groups: (*1*) those manufactured from ligno-cellulosic fibers and fiber bundles where in manufacture the interfelting of the fibers and a natural bond are characteristics, and (*2*) those boards manufactured from a wide range in size and shape of particles ranging from fine elements approaching fibers in size to large flakes which are blended with synthetic resin adhesive and consolidated into boards characterized by the resin bond and usually known as resin-bonded particle boards or more commonly as particle boards.

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[1] Under the standardization procedure of the Society, these definitions are under the jurisdiction of the ASTM Committee D-7 on Wood.

[2] Accepted by the Society at the Annual Meeting, June, 1958.

GENERAL DEFINITIONS

Wood-Base Fiber and Particle Panel Materials.—A generic term applied to a group of board materials manufactured from wood or other ligno-cellulosic fibers or particles to which binding agents and other materials may be added during manufacture to obtain or improve certain properties. Composed of two broad types, fibrous-felted and particle boards.

Fibrous-Felted Boards.—A felted wood-base panel material manufactured of refined or partly refined ligno-cellulosic fibers characterized by an integral bond produced by an interfelting of fibers and in the case of certain densities and control of conditions of manufacture by ligneous bond, and to which other materials may have been added during manufacture to improve certain properties.

Particle Boards.—A panel material composed of small discrete pieces of wood or other ligno-cellulosic materials that are bonded together in the presence of heat and pressure by a synthetic resin adhesive. Particle boards are further defined by the method of pressing. When the pressure is applied in the direction perpendicular to the faces as in a conventional multi-platen hot press, they are defined as flat-platen pressed and when the applied pressure is parallel to the faces, they are defined as extruded.

CLASSIFICATION OF FIBROUS-FELTED BOARDS

Structural Insulating Board.—A fibrous-felted, homogeneous, or laminated panel having a density range of approximately 10 to 26 lb per cu ft, manufactured of refined or partly refined ligno-cellulosic fibers with a primary integral bond, and to which other materials may have been added during manufacture to improve certain properties.

Medium-Density Building Fiberboard.—A felted, homogeneous, or laminated panel having a density range of approximately 26 to 50 lb per cu ft, manufactured of refined or partly refined ligno-cellulosic fibers with a primary integral bond, and to which other materials may have been added during manufacture to improve certain properties.

Hardboard.—A fibrous-felted, homogeneous, or laminated panel having a density range of approximately 50 to 80 lb per cu ft, manufactured under carefully controlled optimum combinations of consolidating pressure, heat, and moisture so that a softening of lignin occurs and the board produced has a characteristic natural ligneous bond, and to which other materials may have been added during manufacture to improve certain properties.

CLASSIFICATION OF PARTICLE BOARDS

Insulating-Type Particle Boards.—A particle board having a density range of approximately 15 to 26 lb per cu ft.

Medium-Density Particle Boards.—A particle board having a density of approximately 26 to 50 lb per cu ft.

Hard-Pressed Particle Boards.—A particle board having a density range of approximately 50 to 80 lb per cu ft.

TERMS RELATING TO WOOD-BASE FIBER AND PARTICLE PANEL MATERIALS

Air-Felting.—Forming of a fibrous-felted board from an air suspension of damp or dry fibers on a batch or continuous forming machine (sometimes referred to as the dry or semi-dry process).

Binder.—An extraneous bonding agent, either organic or inorganic, used to bind particles together to produce a particle board.

Chips.—Small pieces of wood chopped off a block by ax-like cuts as in a chipper of the paper industry, or produced by mechanical hogs, hammermills, etc.

Curls.—Long flat flakes manufactured by the cutting action of a knife in such a way that they tend to be in the form of a helix.

Fibers.—The slender threadlike elements or groups of wood fibers or similar cellulosic material resulting from chemical or mechanical defiberization, or both, and sometimes referred to as fiber bundles.

Flakes.—Specially generated thin flat particles with the grain of the wood essentially parallel to the flat surface and with dimensions usually wide and long with respect to the thickness.

Hot-Pressing.—Process for increasing the density of a wet-felted or air-felted mat of fibers or particles by pressing the dried, damp, or wet mat between platens of hot-press.

Particle.—The aggregate component of a particle board manufactured by mechanical means from wood or other lignocellulosic material (comparable to the aggregate in concrete) including all small subdivisions of wood such as chips, curls, flakes, sawdust, shavings, slivers, strands, wood flour, and wood wool. Particle size may be measured by the screen mesh that permits passage of the particles and another screen upon which they are retained, or by the measured dimensions as for flakes and strands.

Sawdust.—Wood particles resulting from the cutting and breaking action of saw teeth.

Shaving.—A thin slice or strip of wood pared off with a knife, planer, or other cutting instrument in which the cut may be either across, parallel to, or at an angle to the axis of the fibers.

Size.—Asphalt, rosin, wax, or other additive introduced to the stock for a fibrous-felted board, prior to forming, or added to the blend of particles and resin for a particle board, to increase water resistance.

Slivers.—Particles of nearly square or rectangular cross-section with a length parallel to the grain of the wood of at least four times the thickness.

Strand.—A relatively long (with respect to thickness and width) shaving consisting of flat long bundles of fibers having parallel surfaces.

Tempering.—The manufacturing process of impregnating a hardboard with siccative materials such as drying oil blends of oxidizing resin in an amount at least equal to 3 per cent of the weight of the board in nonvolatile solvents which are stabilized by baking or other heating after impregnation. A tempered board is one so treated.

Wet-Felting.—Forming of a fibrous-felted board mat from a water suspension of fibers and fiber bundles by means of a deckle box, fourdrinier, or cylinder board machine.

Wood Flour.—Very fine wood particles generated from wood reduced by a ball or similar mill until it resembles wheat flour in appearance, and of such a size that the particles usually will pass through a 40-mesh screen.

Wood Wool (Excelsior).—Curly, slender strands of wood used as an aggregate component for some particle boards.

TERMS DESCRIBING WOOD-BASE FIBER AND PARTICLE PANEL PRODUCTS

Acoustical Board.—A low-density, sound-absorbing structural insulating board having a factory-applied finish and a fissured, felted-fiber, slotted or perforated surface pattern provided to reduce sound reflection. Usually supplied for use in the form of tiles.

Building Board.—A natural finished multipurpose structural insulating board.

Decorative Hardboard.—Hardboard that is scored or engraved after manufacture or by pressing during manufacture on a patterned caul to produce a decorative surface.

Extruded Particle Board.—Term applied to a particle board manufactured by forcing a mass of particles coated with an extraneous binding agent through a heated die with the applied pressure parallel to the faces and in the direction of extruding.

Flat-Platen Pressed Particle Board.—Term applied to a particle board manufactured by pressing a mass of particles coated with an extraneous binding agent between parallel platens in a hot press with the applied pressure perpendicular to the faces.

Insulating Formboard.—A specially fabricated structural insulating board designed for use as a permanent form for certain poured-in-place roof constructions.

Interior Finish Boards.—Structural insulating board with a factory-applied paint finish, fabricated in the form of plank, board, panels, or tile for interior use.

Insulating Roof Deck Slab.—A relatively thick laminated structural insulating board fabricated for use as a roof deck in plank and beam construction.

Particle Board Corestock.—Common name given to particle board manufactured for use as corestock for veneered products.

Particle Board Panel Stock.—Common name given to particle board manufactured primarily for use as panel material, and in which the surfaces may be treated to obtain decorative effects.

Perforated Hardboard.—Hardboard with closely spaced factory punched or drilled holes.

Planed-to-Caliper Hardboard.—Hardboard that is machined to obtain a close thickness tolerance.

Prefinished Wall Panels.—Hardboards with a factory-applied finish, such as baked-on enamel, lacquer, or similar finish.

Prefinished Particle Board.—Particle board with a factory-applied finish, such as lacquer, baked-on enamel, or similar finish.

Roof Insulation Board.—Structural insulating board fabricated for use as above-deck roof insulation.

Screen-Back Hardboard.—Hardboard with a reverse impression of a screen on the back produced when a damp or wet mat is hot-pressed into a board and dried in the press.

Sheathing.—Structural insulating board for use in housing and other building construction, which may be integrally treated, impregnated or coated to give it additional water resistance.

Shingle Backer.—A specially fabricated sheathing-grade structural insulating board which is used as a backer strip in coursed shingle construction.

Smooth-Two-Side Hardboard.—Hardboard produced from a dry mat pressed between two smooth hot platens.

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Tentative Methods for
ESTABLISHING STRUCTURAL GRADES OF LUMBER[1]

ASTM Designation: D 245 – 57 T

Issued, 1949; Revised, 1957.[2]

These Tentative Methods have been approved by the sponsoring committee and accepted by the Society in accordance with established procedures, for use pending adoption as standard. Suggestions for revisions should be addressed to the Society at 1916 Race St., Philadelphia 3, Pa.

Scope

1. (*a*) These methods[3] cover the basic principles for establishing structural grades of lumber, together with typical examples of grading provisions for each of the use classes. They include the necessary procedures for formulating structural grades of any grade-strength ratio or for evaluating the grade-strength ratios of existing grades.

(*b*) The grading provisions used as illustrations herein are not intended to establish grades for purchase, but rather to show how stress grading principles are applied. Detailed grading rules for commercial stress grades which serve as purchase specifications are established and published by agencies which formulate and maintain such rules and operate inspection facilities covering the various species.

(*c*) The material covered in these methods appears in the following order:

Sections

FOREWORD .... 2 to 4

STRENGTH FACTORS CONTROLLING STRUCTURAL GRADES:

General Considerations 5
Clear Wood Strength .... 6 to 11
Characteristics Affecting Strength .... 12 to 21
Moisture Conditions 22

BASIC PRINCIPLES OF STRESS GRADING:

General Considerations .... 23 and 24
Values of Strength Ratios .... 25 to 28
General Requirements for Stress Grades .... 29 to 40
Optional Requirements for Stress Grades .... 41 to 45
EXAMPLES OF STRUCTURAL GRADING PROVISIONS .... 46 to 50

BASIC STRESSES:

Recommended Basic Stress Values 51
Principles in the Determination of Basic Stresses .... 52 to 58

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[1] Under the standardization procedure of the Society, these methods are under the jurisdiction of the ASTM Committee D-7 on Wood.

[2] Revision accepted by the Society at the Annual Meeting, June, 1957.

Prior to their present publication as tentative, these methods were published as tentative from 1926 to 1927, being revised in 1927. They were adopted in 1927, revised in 1929, 1930, and 1933, but were further revised and republished as tentative from 1936 to 1937. They were again adopted in 1937, and published as standard from 1937 to 1949, when they were revised and reverted to tentative.

[3] These methods are in agreement with the principles set forth in the "Wood Handbook," revised, 1955, published by the U. S. Department of Agriculture, available from the Superintendent of Documents, Government Printing Office, Washington 25, D. C.

APPLICATION OF STRESSES:

Sections
General Considerations........ 59
Modifications of Stress........ 60 to 67
Example of Working Stress Calculation.................. 68

FOREWORD

Need for Lumber Grading

2. (*a*) Individual pieces of lumber, as they come from the saw, represent a wide range in quality and appearance with respect to freedom from knots, cross grain, shakes, and other characteristics. Such random pieces likewise represent a wide range in strength, utility, serviceability, and value. One of the obvious requirements for the orderly marketing of lumber is the establishment of grades that permit the procurement of any required quality of lumber in any desired quantity. Many of the grades for lumber are established on the basis of the appearance and physical characteristics of the piece, but without regard for strength. Other grades, called structural or stress grades, are established on the basis of features that relate to strength and strength uses. They afford material of designated minimum strength on which structural design can be based.

(*b*) Maximum economy of material is obtained when the range in strength within a grade is limited and when all structural units are stressed to the full allowable strength of the grade. The function of an efficient structural lumber grading specification is to classify lumber of any species into quality classes, or grades, by properly defining or limiting the permissible characteristics affecting strength; in this way, definite minimum strength is assured and maximum efficiency in use is obtained.

(*c*) The development of structural grading rules and of working stresses for structural lumber is based on extensive research covering tests of small clear specimens and of full-size structural members. Detailed studies have included the strength and variability of clear wood, and the effect on strength from various factors such as density, knots and other defects, seasoning, duration of stress, and temperature.

How Structural Grading is Accomplished

3. (*a*) Structural grading is accomplished from a visual examination of the piece, in which the location as well as the size and nature of the knots and other features appearing on the surfaces are evaluated. Basic principles of structural grading have been established that permit the evaluation of any timber in terms of a strength ratio. The strength ratio of a structural timber is the ratio of its strength to that which it would have if no weakening characteristics were present. Thus a timber with a strength ratio of 75 per cent would have 75 per cent the strength of the clear piece. Basic working stresses established for each species of wood are applicable to such clear pieces, so that the working stress for a timber with a strength ratio of 75 per cent would be 75 per cent of the basic stress for its species.

(*b*) In grading structural timber, all four faces are considered. The most critical one of the faces determines the strength ratio or the grade of the piece.

Use Classification of Structural Lumber

4. (*a*) The various factors affecting strength differ in their effect, depending on the kind of stress involved. Hence in the establishment of structural grades, efficiency is served by consideration of the type of use. Many structural grades are established on the basis of their use as "joists and planks," "beams and stringers," and "posts and timbers."

Boards 1 in. (nominal) in thickness constitute a fourth use class if graded for stress. These classes are defined in Section 24.

(*b*) The assignment of names indicating the uses for the various classes of structural lumber does not preclude their use for other purposes. There is need for compression and tension values for joists and planks if used in the chord or web members of timber trusses. Posts and timbers may give service as beams. The principles of stress grading permit the assignment of any kind of working stress to any of the classes of structural lumber, whether graded primarily for that stress or not. Recommendations of working stress may include all stresses for all grades or use classes.

(*c*) The same broad applicability of the principles of stress grading permits the formulation of combination or all-purpose grades of lumber. Thus, a single grade of structural lumber may be designed for all of the strength uses of joists and planks, beams and stringers, and posts and timbers. While such universal application may result in loss of efficiency in some particulars, it offers the advantage of a more simple system of stress grades for the use of the structural designer.

(*d*) Round timbers (poles or piles) are sometimes used where they must be graded for strength and working stresses assigned. While not included with the use classes for lumber, the principles of grading for strength are applicable, with suitable modifications, to such material.

STRENGTH FACTORS CONTROLLING STRUCTURAL GRADES

GENERAL CONSIDERATIONS

Factors Influencing Strength

5. The most important factors that influence the strength of structural lumber are the strength and variability of the clear wood, the size, number and location of characteristics affecting strength, and the moisture conditions. These factors must all be considered in grading if the maximum utilization is to be obtained from the lumber used.

CLEAR WOOD STRENGTH

Variability

6. The various species of wood used structurally differ in their strength properties. There is likewise a variability in the strength of clear wood within each species, resulting from natural and normal differences in the growth of individual trees. This variability of strength is associated with variations in density which are recognized in the rules for strength grading.

Density

7. (*a*) The density of the wood substance of all species is practically the same. The dry weight is, therefore, a measure of the amount of wood substance present; and on the amount of wood substance present depends the strength of the clear wood. Pieces of exceptionally light weight should be excluded from stress grades.

(*b*) In southern pine and Douglas fir, the proportion of summerwood, the darker portion of the annual ring furnishes a practical means of estimating density. Material having one third or more summerwood and a required rate of growth is designated as "dense". Selection of dense lumber of these species assures material of the highest character from the standpoint of strength, and uniformity in strength of the clear wood.

(*c*) In acceptance for density, the contrast in color between springwood and summerwood should be distinct.

Absence of contrast occasionally occurs in apparently dense material usually characterized by very wide and eccentric annual growth rings, having a more or less dark-reddish to brown color. This growth occurs on the under side of limbs and leaning trunks of coniferous trees, and is called compression wood. It has a decided end shrinkage and is weak in tension. Material of this character in even a small part of a cross-section is undesirable in high-class structural lumber. In the application of the density rule, compression wood is excluded because it fails to meet the requirement of a distinct contrast in color between springwood and summerwood.

Close Grain

8. In Douglas fir, southern yellow pine, and redwood, "close grain," defining selected material of a limited rate of growth, is accepted as a basis for an increased working stress. The increase is not as great as that achieved by selection for percentage of summerwood, but for many purposes, selection for close grain will assure material of suitable type. Close grain in Douglas fir or southern yellow pine is required to have 6 but not more than 30 rings per inch. Close grain in redwood is based on slightly different limits in the number of rings per inch, but assures an increase of strength comparable to that in Douglas fir or southern yellow pine.

Medium Grain

9. In softwood species such as Douglas fir and the southern pines, rapidly grown wood during the early years of the life of the tree is deficient in strength and stiffness compared to wood that grows more slowly. A requirement of "medium grain," not less than four rings per inch, serves to exclude or closely limit such material. Most structural grading rules include that requirement. The standard strength test values to which working stresses are related are on material practically all of which meets the requirement of medium grain.

Heartwood and Sapwood

10. (*a*) Heartwood and sapwood have been found to be of equal strength, and no requirement of heartwood need be made when strength alone is the governing factor. Heart requirement, when durability of untreated material under exposure is a factor, as in bridges, trestles, docks, and piers, or in damp buildings or buildings in which conditions of high humidity prevail, may be specified in any grade, according to exposure and use.

(*b*) When preservative treatment is to be applied, there should be no restriction of sapwood, as sapwood is easier to treat than heartwood and a large amount is to be preferred. It is customary in some species to specify a minimum thickness of sapwood in round poles or piles for preservative treatment.

Decay

11. Ordinarily, the extent of decay in wood is difficult to determine, and its effect on strength and shock resistance is greater than visual observation would indicate. Decay is generally excluded from strength grades of lumber. Limited amounts may be permitted in some of the lower grades and for light framing or similar less exacting uses.

CHARACTERISTICS AFFECTING STRENGTH

Slope of Grain

12. (*a*) Slope of grain, resulting either from diagonal sawing or from spiral or twisted grain in the log, is limited in accordance with its effect upon strength. The effect is measured by the angle

between the direction of the fibers and the axis of the piece (or edge, if parallel to that axis). The angle is usually expressed as a slope. For instance, a slope of grain of 1 in 15 means that the grain deviates 1 in. from the edge in a distance of 15 in. The reduction of strength assumed in structural timbers is more than that observed in tests of small clear wood specimens. This is because: (*1*) where combined diagonal and spiral slopes occur, or where the timber does not show true radial or tangential faces, the true slope is often greater than is indicated from the usual surface measurements; and (*2*) the effect of the same slope may be greater in timbers than in small clear specimens because of the greater shrinkage stresses brought on during seasoning of the timbers.

(*b*) There is negligible reduction in strength from cross grain in a timber subjected to bending or tension until a slope of 1 in 40 is reached. Permissible slopes of grain range from 1 in 20 for nearly clear material to 1 in 8 for grades having one half the strength of clear wood.

(*c*) In a post or column, the influence on strength of cross grain and of the checks following the grain is much less than in a piece in bending or tension, but excessive cross or spiral grain is objectionable on account of the twisting and diagonal checks which occur in seasoning. Permissible slopes of grain in short columns range from 1 in 15 for nearly clear material to 1 in 6 for grades having one half the strength of clear wood.

(*d*) Slope of grain in most structural timbers should be measured over a distance that will assure the determination of the general slope of grain not influenced by short, local deviations such as those around knots. Distances of 2 or 3 ft ordinarily meet this requirement. In the smaller strength-graded parts, such as ladder rails, local deviations that might cut through the full cross-section are more closely restricted. For a timber in bending, cross grain is of greatest importance on the top and bottom faces and in the central portion of the length of noncontinuous spans. If meeting the grade requirement in these locations, cross grain may be somewhat greater elsewhere.

Knots

13. (*a*) The influence of a knot in a beam is determined by its location, and the area of its projection on the cross-section of the piece, the method of measurement being such as to give the best approximation of this influence.

(*b*) Knots in posts and large beams are likely to show on one face only or to run diagonally through the piece and reduce strength in proportion to their size as measured in relation to the size of the piece.

(*c*) In side-cut joists and planks, the knot is likely to run directly through the piece; and when used on edge, the strength as affected by a knot on a wide face, is measured by the square of the effective depth of the piece, assuming the knot in its worst position near the edge of the piece. In most grades, the reduction in strength due to the knot is approximately twice the ratio of the size of the knot to the width of the face. In boxed-heart joists and planks, corner knots are restricted in the same way as in beams and stringers.

(*d*) On narrow faces of boxed-heart pieces; on center lines of wide faces of dimension sizes used on edge, as joists; and on wide faces of such material used flat, as planks; the influence of a knot is directly proportional to its size in relation to the size of the piece, as in posts and large beams. Attention need not be given to knots on narrow faces of side-cut joists and planks (pieces not containing the pith), as such knots will also show on wide faces, and their limitation there is sufficient. In boxed-heart pieces (pieces containing the pith), a knot may show only on a narrow face, and its limitation there is necessary. Corner knots or knots extending entirely across a face of a side-cut joist are measured on their ends rather than in the full exposed length.

(*e*) Knot limitations on edges of wide faces of material for use as joists are more severe than would be required for use flat as planks, the sizes applying along the center lines of the wide faces as joists being those which could theoretically apply at any point across the width if used only as planks. It has been found, however, that under practically all conditions of use, knots along the edges of planks are more objectionable than knots along the center lines and this is recognized in some commercial yard grades of planks in a stricter limitation of knots along the edges of the wide faces than along the center lines. The same knot limitations are applied, therefore, to material to be used either as joists or planks, and the same working stresses are assigned for use either on edge or flat.

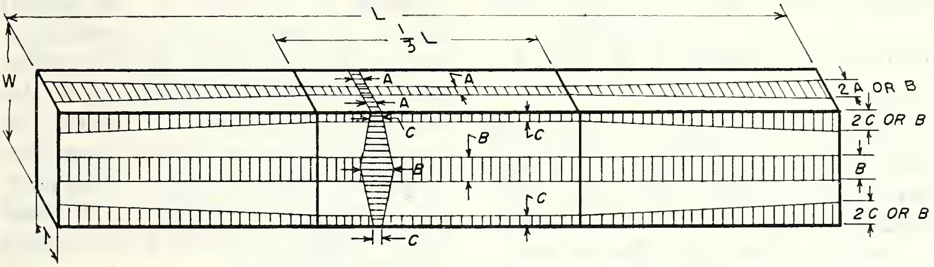


FIG. 1.—Maximum Size of Knots Permitted in Various Parts of Joists and Planks, and Beams and Stringers:

A, maximum size on narrow face in middle third of length with a uniform increase to 2*A* but not to exceed *B*, at the ends.

B, maximum size at center of wide face.

C, maximum size at edge of wide face in middle third of length with a uniform increase to 2*C* but not to exceed *B* at the ends and a uniform increase to *B* at the center of the wide face. In beams and stringers, *A* and *C* are equal.

L, length.

W, width of wide face.

T, width of narrow face.

(*f*) In both joists and beams, knots reduce strength most along the top and bottom edges, through the center portion of length. The sizes of knots permitted in various portions of a joist or beam are limited in accordance with the stresses, and are allowed to increase toward the ends and toward the center lines of the vertical faces. The size of a knot on the narrow face or at the edge of a wide face may be increased uniformly, outside the middle third of the length, to twice that size at the ends, but not larger than the knot permitted at the center of the wide face. The size of a knot at the edge of a wide face may be increased uniformly to the size permitted at the center of the wide face. Fig. 1 illustrates these increases of knot sizes.

(*g*) There is proportionally more distortion of grain around a large knot than around a smaller one; therefore, shrinkage in seasoning causes greater internal stresses, and there is proportionally more effect on strength from the large than from the small knot. For this reason, knot sizes are increased proportionately to width of faces only up to 6-in. narrow faces of beams and stringers; to 12-in. wide faces of joists and planks, and beams and stringers; and to 12-in. faces of posts and timbers. Beyond these limits, the increase of knot sizes is proportional to the square root of the increase of the width of the face. To illustrate, if a 3-in. knot in a 12-in. face of a timber causes a strength reduction of 25 per cent, the same reduction would occur in a 16-in. face from a knot whose size is $\sqrt{\frac{16}{12}} \times 3 =$ 3.47 in.

(*h*) In small pieces of lumber, the distortion of grain caused by a knot may occupy a large part of the cross-section, though the knot itself is partly or entirely absent. In like manner, a knot at the center of a wide face may cause distortion extending to the edge of that face. For this reason, the grading for strength of pieces 3 by 3 in. or smaller is more difficult than the grading of larger pieces, and it is ordinarily not done. Where such small pieces are graded for strength, all knots should be considered and limited as if at the edge of the face where they appear.

(*i*) In joists and planks, the mean or average diameter of a knot is taken as its size. In such thin and relatively wide material, whether used on edge or flat, this is a safe measure of the influence of knots on strength, and has the commercial advantage of being directly applicable to yard grades of lumber. This method of measurement will exclude damaging spike knots, and can be applied to them as well as to round or oval knots.

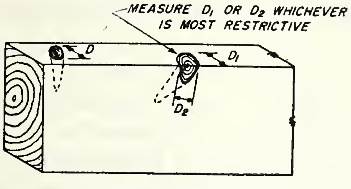
(*j*) On the top or bottom of a beam or stringer, or a boxed-heart joist, the influence of knots is measured largely by the surface fibers cut. Therefore, the projection of a knot on a line at a right angle to the edge is used.

(*k*) On the vertical faces of a beam or stringer, the depth to which a knot penetrates is of great importance, while the influence of the number of surface fibers cut, and the amount of grain distortion, is considerably less important than on the horizontal faces. Therefore, the smallest diameter of the knot is used. One of the best examples illustrating the reason for the smallest diameter being taken on the vertical face is the splitting of a boxed-heart timber into two pieces. The long spike knots that might be opened up in this way would be no more injurious to the strength of the two pieces than they would as a single knot in a boxed-heart piece, and the two pieces so cut would be less subject to seasoning checks than a boxed-heart piece.

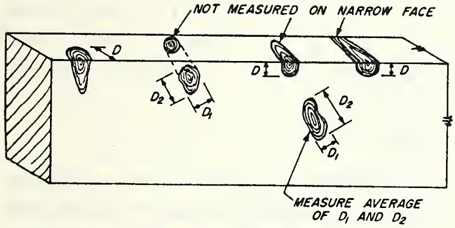
(*l*) Compression members, such as posts and timbers, are stressed about equally throughout; and the same size of knot is permitted at any place in the piece. Since the effect of a knot is less on compressive than on bending strength, it is sufficient to measure knots by their smallest diameters. Where compression members have faces of unequal width, a knot of a given size has about the same effect on strength whether in the wider or in the narrower face.

(*m*) Intergrown or live knots offer some resistance to stress, while encased knots or knotholes are of little or no value. On the other hand, the distortion of fibers is greater around a live or intergrown knot than around a dead or encased knot of the same size. Strength effects are thus roughly equalized, and no distinction is made in strength grading between live knots, dead knots, and knotholes.

(*n*) The effect of knots is much less on stiffness than on strength. Although the zone of distorted fibers around a knot has less stiffness than straight-grained wood, such zones generally comprise only a minor part of the volume of a structural timber, while stiffness reflects the character of all parts.



BOXED HEART


NOT MEASURED ON NARROW FACE
D
D
D
D_2
D_1
D_2
D_1
MEASURE AVERAGE OF D_1 AND D_2

SIDE CUT

Fig. 2.—Measurement of Knots in Joists and Planks.

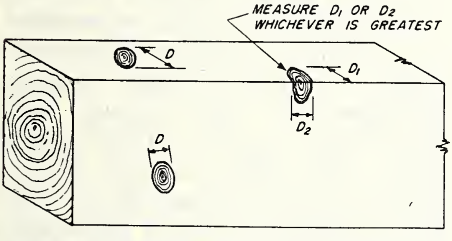


Fig. 3.—Measurement of Knots in Beams and Stringers.

(*o*) Figure 2 illustrates the measurement of knots in joists and planks. Figure 3 illustrates the measurement of knots in beams and stringers. Figure 4 illustrates the measurement of knots in posts and timbers or other compression members.

Sum of Sizes of Knots

14. The distribution and sum of the diameters of knots are of importance, as well as the maximum size of a single knot. In beams and stringers up to 20 ft long, the sum of the sizes of all knots within the middle half of the length of a face is limited to four times the size of the largest knot allowed on that face. Limits in longer beams and stringers are proportionate. In joists and planks, or in any structural timber to be stressed in axial compression or tension, the sum of the sizes of all knots in any 6 in. of length of the piece is limited to twice the size of the largest permitted single knot. Two or more knots of maximum or near maximum permissible size are not allowed in the same 6 in. of length on any face.

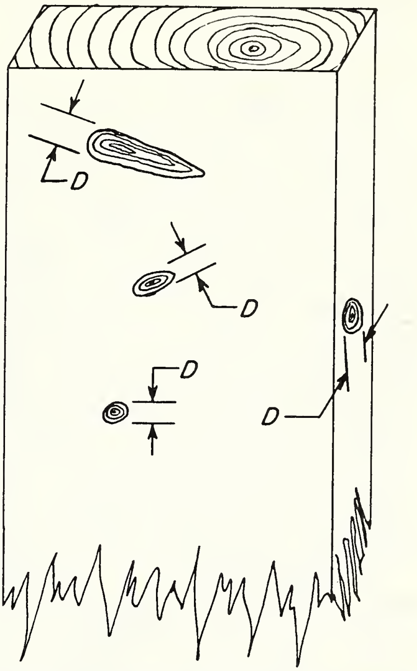


Fig. 4.—Measurement of Knots in Posts and Timbers or Other Compression Members.

Cluster Knots

15. Cluster knots are prohibited in structural timbers because neither the sizes of the individual knots nor that of the cluster are good measures of the extent of distortion of the grain and the resultant effect on strength. Two or more knots closely spaced, with the fibers deflected around each knot individually, are not a cluster.

Shakes and Checks

16. (*a*) Shakes reduce the area of a beam acting in resistance to shear, and the limitations placed on shake in such material are based on this reduction. Checks and splits are limited on the same basis as shakes, and no combination of shakes, checks, and splits is permitted that would reduce strength to a greater extent than would the allowable size of either separately. Shake in green material is assumed to reduce shearing stress in direct proportion to its extent. A greater amount of shake is permitted in seasoned material, made up for by the increased resistance of the remaining cross-section when seasoned.

(*b*) In joists and planks, and beams and stringers, shake in green material is permitted in direct proportion of increase from none in a grade of the strength of green, clear wood to one half the thickness of the piece in a grade having one half the strength of green, clear wood. In seasoned material, shake is similarly permitted from one ninth the thickness of the piece in a grade of the strength of green, clear wood to five ninths the thickness of the piece in a grade having one half the strength of green, clear wood. The maximum effect from shakes is to reduce the strength by half, since a piece split completely in two has half the strength that it would have if no shake were present.

(*c*) Since shear stress in most joists or beams is greatest near the ends, the restrictions are applied only for a distance from each end equal to three times the height of the piece. (Height equals width of wide face.) Since shear stress is greatest near the neutral axis, the restrictions also are applied only in the middle one half of the height of the piece; and only the shakes, checks, and splits in this section are measured.

(*d*) Shakes and checks, as a rule, have little influence on the strength of a post or column, so long as the piece can act as a unit in compression. A limitation on shakes and checks in posts and timbers is made for the sake of appearance and, in exterior exposures, to reduce the opportunity for moisture to enter and permit decay to start. Such limitations are not related to specific strength ratios.

Wane

17. Wane is limited by considerations of required bearing or nailing surfaces, or for the sake of appearance, rather than by its effect on strength. The reduction of strength from the amount of wane permissible from such considerations is negligible. A combination of wane and knots has a cumulative effect on strength. Since, however, maximum wane and maximum knots rarely occur together in the central part of the length, and the effect of wane is small in comparison to the effect of knots, it is usually unnecessary to give attention to the combination.

Compression Failures

18. Compression failures are incipient failures resulting from a previous overstress in compression parallel to grain; their effect is greatest on tensile strength and shock resistance. They may be an important strength-reducing factor in old timbers that have been overloaded

in service. Compression failures are specifically prohibited in some specialized strength-graded parts such as ladder rails.

Pitch Pockets

19. Pitch pockets ordinarily do not affect the strength of structural lumber. A large number, however, indicates a general lack of bond, and such a piece should be carefully inspected for shakes.

Holes

20. Holes may be caused by the dropping out of knots, by the "peck" to which some species, principally cypress, are subject, by insects and worms that attack wood, or by tools used in handling logs or timbers. The effect of knotholes or of loose or encased knots is likely to be less than that of tightly intergrown knots of the same size because of the usually lesser deviation of grain. The effect of holes from other causes is due principally to the absence of wood and the cutting across of fibers, and as such holes do not cause deviations of grain, the effect is less than that of knots of the same sizes.

Combination of Characteristics

21. Where combinations of strength-reducing characteristics are present, their combined effects are taken into account in structural grading. Grading rules commonly prohibit any combination which, in the judgment of the grader, will unfit the piece for its intended use. Relative density, however, may compensate to some extent for any combination that reduces strength. When, therefore, a particular piece is questionable from a combination of characteristics, but is of average or higher density, the relative effect of all features on the properties concerned may be considered.

MOISTURE CONDITIONS

Effects of Seasoning

22. (*a*) Seasoning affects the strength of structural lumber both directly and indirectly. The direct effect of loss of moisture is the stiffening and strengthening of the wood fibers. This increase in strength, however, may be accompanied by checking, splitting, warping, or twisting. As a consequence, some of the possible gain in strength due to drying is lost.

(*b*) In material 4 in. and less in thickness, the development of defects during seasoning does not offset the increase in strength from drying as much as in larger sizes. In these sizes used in dry locations, higher working stresses in extreme fiber in bending can be permitted with the same size defects, or greater defects can be permitted with the same working stresses. This gain in strength is greater in the high grades than in the lower grades. It is commonly taken into account by increasing the strength ratio by half of its excess over 50 per cent; thus, material having a strength ratio of 60 per cent when green is given a strength ratio of 65 per cent when dry.

(*c*) Seasoning defects have less effect on compressive than on bending strength. Posts and columns thus show more gain in strength with drying than do timbers subjected to bending forces. Tests have shown that the gain may be recognized by a 10 per cent increase of working stress in all sizes and grades. In material 4 in. or less in thickness, the 10 per cent increase may be made in addition to the increase of strength ratio by half of its excess over 50 per cent.

(*d*) During use, construction material is subject to varying conditions of moisture, from the dry location of a heated building to the continually wet condition of some pier and dock timbers. These conditions must be taken into account in determining working stresses.

BASIC PRINCIPLES OF STRESS GRADING

General Considerations

Strength Ratio and Working Stress

23. (*a*) The strength ratio of a grade represents the remaining strength after making allowance for the maximum effect of the permitted knots, cross grain, shakes, and the like on a green piece. Thus, a strength ratio of 75 per cent applies to a grade in which the maximum reduction in strength from that of green, clear wood is 25 per cent.

(*b*) Working stresses for any grade of structural lumber are found by multiplying the strength ratio by the basic stress. Basic stress is a generalized working strength value for the clear wood of a species. It contains all of the factors appropriate to the nature of structural lumber and the conditions under which it is used, except for those characteristics which are accounted for in the strength ratio. Basic stresses are given in Sections 51 to 58 of these methods.

(*c*) "Beams and stringers," "joists and planks," and "posts and timbers" may be described under the same grade name, but the requirements need not be such as to afford the same strength ratio in each use class. Also, working stress in the extreme fiber of pieces used in bending is determined by the permitted knots and cross grain, whereas shearing stress depends on shakes and checks. Consequently, strength ratios for shear and for stress in extreme fiber may differ in the same grade, and a ratio for each kind of stress is necessary to characterize a grade of "beams and stringers" or of "joists and planks."

(*d*) Economy may be served by specifying these ratios in such relation to each other that the allowable working stresses for shear and for extreme fiber will be in balance, under the loading for which the members are designed. Furthermore, timbers of high strength ratio should not be specified for use where stiffness is the controlling factor, because stiffness varies but little with the grade.

(*e*) Strength ratios are applied to stresses in transverse bending, tension parallel to grain, compression parallel to grain, and horizontal shear in beams. Modulus of elasticity and compression perpendicular to grain are little affected by strength-reducing characteristics, and strength ratios of 100 per cent are assumed for all grades.

Use Classes of Structural Lumber

24. (*a*) The effects of knots, deviations of grain, shakes, and checks on the strength of a timber vary with the loading to which the piece is subjected. Also the effect of seasoning varies with the size of the timber. Structural lumber is therefore often classified according to its size and use. Four classes are widely used, as follows:

(*1*) *Joists and Planks.*—Pieces of rectangular cross-section, 2 to 4 in. thick and 4 or more in. wide (nominal dimensions), graded primarily for strength in bending edgewise or flatwise but also frequently used where tensile or compressive strength is important. Material 2 in. (nominal) thick is often placed in grades separate from the heavier joists and planks.

(*2*) *Beams and Stringers.*—Pieces of rectangular cross-section, 5 by 8 in. (nominal dimensions) and up, graded for strength in bending when loaded on the narrow face.

(3) *Posts and Timbers.*—Pieces of square or nearly square cross-section, 5 by 5 in. (nominal dimensions) and larger, graded primarily for use as posts or columns but adapted to miscellaneous uses in which bending strength is not especially important.

(4) *Structural Boards.*—Lumber of 1-in. (nominal) thickness used in lightweight trusses or other structural elements, or in glued laminated structural members where the principal stresses are in axial compression or tension. Boards for common purposes such as sheathing, finish, or boxes, are not included.

(*b*) The principles of stress grading make possible the assignment of bending stresses to posts and timbers, compression or tension stresses to joists and planks and beams and stringers, or stresses for flatwise bending to beams and stringers. Combined uses for any of the use classes are thus made possible. It is likewise possible to formulate combination or all-purpose grades of structural lumber, designed for all the strength uses of all of these use classes.

VALUES OF STRENGTH RATIOS

Slope of Grain

25. Table I gives strength ratios, corresponding to various slopes of grain, for stress in extreme fiber in bending, tension parallel to grain, and compression parallel to grain.

Knots

26. Strength ratios for various combinations of size of knot and width of face are given in Tables II, III, and IV. The use of these tables is illustrated by the following example: The sizes of knots permitted in a 8- by 16-in. (nominal) beam in a grade having a strength ratio of 70 per cent for stress in extreme fiber in bending are desired. The smallest ratio in the column for 8-in. face in Table II that equals or exceeds 70 per cent is opposite $2\frac{1}{8}$ in. in the size-of-knot column. A similar ratio in the column for 16-in. face in Table III is opposite $4\frac{1}{4}$-in. Hence, the permissible sizes are $2\frac{1}{8}$ in. on the 8-in. face and $4\frac{1}{4}$ in. on the 16-in. face.

Shakes, Checks, and Splits

27. Strength ratios for various combinations of thickness of piece with size of shakes, checks, or splits are given in Table V. The Table is in two sections, one for green and the other for seasoned lumber. Values for green lumber are found from the equation $S = \dfrac{100 - R}{100}$, and values for seasoned lumber from the equation $S = \dfrac{900 - 8R}{900}$, where R is the strength ratio in per cent, and S is the permissible size of shake, check, or split, stated as a fraction of the thickness at the end of the piece. Strength ratios below 50 per cent are not used (Section 16 (*b*)).

TABLE I.—STRENGTH RATIOS CORRESPONDING TO VARIOUS SLOPES OF GRAIN.

Slope of Grain	Maximum Strength Ratio, per cent	
	Bending or Tension Parallel to Grain	Compression Parallel to Grain
1 in 6	...	56
1 in 8	53	66
1 in 10	61	74
1 in 12	69	82
1 in 14	74	87
1 in 15	76	100
1 in 16	80	...
1 in 18	85	...
1 in 20	100	...

Example of Grade Evaluation

28. (*a*) It is desired to find the strength ratios for a grade of joists and

TABLE II.—STRENGTH RATIOS CORRESPONDING TO VARIOUS COMBINATIONS OF SIZE OF KNOT AND WIDTH OF NARROW FACE.[a,b]

NOTE.—This table covers beams and stringers or joists and planks with knots on narrow face within middle third of length of piece. Strength ratios are for stress in extreme fiber in bending or tension parallel to grain.

Size of Knot, in.	Percentage Strength Ratio When Nominal Width of Narrow Face in Inches is:									
	2	3	4	5	6	8	10	12	14	16
¼	90	93	95	96	96	97	97	97	98	98
⅜	83	89	92	93	94	95	96	96	96	97
½	77	85	88	91	92	93	94	95	95	95
⅝	71	81	85	88	90	92	92	93	94	94
¾	65	76	82	86	88	90	91	92	92	93
⅞	58	72	79	83	86	88	89	90	91	91
1	52	68	76	81	84	86	88	89	89	90
1⅛	46	64	73	78	82	84	86	87	88	89
1¼	26	60	70	76	80	83	84	86	87	88
1⅜	..	56	67	73	78	81	83	84	85	86
1½	..	51	63	71	76	79	81	83	84	85
1⅝	..	47	60	68	74	77	80	81	83	84
1¾	..	35	57	66	71	75	78	80	81	83
1⅞	..	30	54	63	69	73	76	78	80	81
2	..	25	51	61	67	72	75	77	79	80
2⅛	..	..	48	58	65	70	73	75	77	79
2¼	..	..	45	56	63	68	71	74	76	77
2⅜	..	..	36	53	61	66	70	72	74	76
2½	..	..	32	51	59	64	68	71	73	75
2⅝	..	..	29	48	57	63	67	70	72	74
2¾	..	..	25	46	55	61	65	68	70	72
2⅞	..	..	..	..	53	59	63	67	69	71
3	..	..	..	..	51	57	62	65	68	70
3⅛	..	..	..	..	..	55	60	64	66	68
3¼	..	..	..	..	..	54	59	62	65	67
3⅜	..	..	..	..	..	52	57	61	64	66
3½	..	..	..	..	..	50	55	59	62	65
3⅝	..	..	..	..	..	..	54	58	61	63
3¾	..	..	..	..	..	..	52	56	59	62
3⅞	..	..	..	..	..	..	50	55	58	61
4	..	..	..	..	..	..	..	53	57	60
4⅛	..	..	..	..	..	..	..	52	55	58
4¼	..	..	..	..	..	..	..	50	54	57
4⅜	..	..	..	..	..	..	..	..	53	56
4½	..	..	..	..	..	..	..	..	51	54
4⅝	..	..	..	..	..	..	..	..	50	53
4¾	..	..	..	..	..	..	..	..	..	52
4⅞	..	..	..	..	..	..	..	..	..	51

[a] Strength ratios of 45 per cent or higher are based on the relation of the size of knot to the nominal width of face; lower ratios are based on the relation of the size of knot to the actual standard dressed width of face. In tabulating the sizes of knots, the rule used in approximating decimals by common fractions with ⅛-in. intervals has the effect of subtracting $\frac{1}{24}$ in. from the size of each knot. For example, the strength ratios listed for a 3½-in. knot are those which actually would obtain for a size of $3\frac{11}{24}$ in. In view of the allowance thus introduced and the fact that nominal instead of actual widths of face are used, the strength ratios given should be taken as maximum values.

[b] Sizes of knots permitted for a given strength ratio in narrow faces wider than 6 in. in beams and stringers are increased only in proportion to the square root of the increase of width of the face. Below these limits, the sizes permitted are proportioned to the width of the face.

TABLE III.—STRENGTH RATIOS CORRESPONDING TO VARIOUS COMBINATIONS OF SIZE OF KNOT AND WIDTH OF WIDE FACE.[a, b]

NOTE.—This table covers:

1. Beams and stringers or joists and planks with knots along the center line of wide face at any point in the length of the piece. Strength ratios are for stress in extreme fiber in bending or tension parallel to grain.
2. Posts and timbers with knots at any point on any face. Strength ratios are for stress in compression parallel to grain.
3. One-inch boards with knots anywhere in wide face. Strength ratios are for all stresses.

Size of Knot, in.[c]	Percentage Strength Ratio When Nominal Width of Wide Face in Inches is:												
	3	4	5	6	8	10	12	14	16	18	20	22	24
¼	..	95	96	96	97	98	98	98	98	99	99	99	99
½	..	88	91	92	94	95	96	96	97	97	97	97	97
¾	..	82	86	88	91	93	94	94	95	95	95	96	96
1	..	76	81	84	88	90	92	93	93	93	94	94	94
1¼	..	70	76	80	85	88	90	91	91	92	92	93	93
1½	..	63	71	76	82	85	88	89	89	90	91	91	91
1¾	..	57	66	71	79	83	86	87	88	88	89	89	90
2	..	51	61	67	75	80	84	85	86	87	87	88	88
2¼	..	45	56	63	72	78	82	83	84	85	86	86	87
2½	..	32	51	59	69	75	79	81	82	83	84	85	85
2¾	..	25	46	55	66	73	77	79	80	82	82	83	84
3	..	..	36	51	63	70	75	77	79	80	81	82	83
3¼	..	..	31	47	60	68	73	75	77	78	79	80	81
3½	..	..	25	37	57	65	71	73	75	76	78	79	80
3¾	..	..	..	33	54	63	69	71	73	75	76	77	78
4	..	..	..	28	50	60	67	69	71	73	74	76	77
4¼	..	..	..	..	47	58	65	67	70	71	73	74	75
4½	..	..	..	..	41	55	63	66	68	70	71	73	74
4¾	..	..	..	..	37	53	61	64	66	68	70	71	72
5	..	..	..	..	34	50	59	62	64	66	68	70	71
5¼	..	..	..	..	31	48	57	60	62	65	66	68	69
5½	..	..	..	..	27	45	54	58	61	63	65	66	68
5¾	..	..	..	..	..	40	52	56	59	61	63	65	66
6	..	..	..	..	..	37	50	54	57	59	61	63	65
6¼	..	..	..	..	..	35	48	52	55	58	60	62	63
6½	..	..	..	..	..	32	46	50	53	56	58	60	62
6¾	..	..	..	..	..	29	42	48	52	54	57	59	60
7	..	..	..	..	..	27	39	46	50	53	55	57	59
7¼	..	..	..	..	..	..	37	42	48	51	53	56	57
7½	..	..	..	..	..	..	35	40	46	49	52	54	56
7¾	..	..	..	..	..	..	33	38	42	48	50	53	55
8	..	..	..	..	..	..	31	36	40	46	49	51	53
8¼	..	..	..	..	..	..	29	34	38	42	47	49	52
8½	..	..	..	..	..	..	26	32	37	40	45	48	50

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[a] See footnote *a* of Table II.

[b] Sizes of knots permitted for a given strength ratio in wide faces wider than 12 in. in beams and stringers and joists and planks, or faces wider than 12 in. in posts and timbers, are increased only in proportion to the square root of the increase of width of the face. Below these limits, the sizes permitted are proportioned to the width of the face.

[c] Ratios corresponding to other sizes of knot can be found by interpolation.

TABLE IV.—STRENGTH RATIOS CORRESPONDING TO VARIOUS COMBINATIONS OF SIZE OF KNOT AND WIDTH OF WIDE FACE.[a,b]

NOTE.—This table covers joists and planks with knots at edge of wide face within middle one-third of length of piece. Strength ratios are for stress in extreme fiber in bending or tension parallel to grain.

Size of Knot, in.	Percentage Strength Ratio When Nominal Width of Wide Face in Inches is:													
	2	3	4	5	6	8	10	12	14	16	18	20	22	24
¼	80	86	90	92	93	95	96	97	97	97	97	97	97	98
⅜	70	79	84	87	89	92	93	94	95	95	95	96	96	96
½	60	72	78	82	85	89	91	92	93	93	94	94	94	95
⅝	50	65	73	78	81	86	89	90	91	92	92	93	93	93
¾	32	58	68	74	78	83	86	88	89	90	91	91	91	92
⅞	..	52	63	69	74	80	84	87	88	88	89	89	90	90
1	..	46	58	65	71	77	82	85	86	87	87	88	89	89
1⅛	..	34	53	61	67	75	79	83	84	85	86	86	87	88
1¼	..	29	49	57	64	72	77	81	82	83	84	85	86	86
1⅜	..	..	40	54	60	69	75	79	80	82	83	83	84	85
1½	..	..	36	50	57	67	73	77	79	80	81	82	83	84
1⅝	..	..	32	47	54	64	71	75	77	78	80	81	81	82
1¾	..	..	28	40	51	62	69	74	75	77	78	79	80	81
1⅞	..	..	..	36	48	59	67	72	74	75	77	78	79	80
2	..	..	..	33	45	57	65	70	72	74	75	76	77	78
2⅛	..	..	..	30	40	55	63	68	70	72	74	75	76	77
2¼	..	..	..	27	37	52	61	67	69	71	72	73	75	76
2⅜	..	..	..	..	34	50	59	65	67	69	71	72	73	74
2½	..	..	..	..	32	48	57	63	66	68	69	71	72	73
2⅝	..	..	..	..	29	46	55	62	64	66	68	69	71	72
2¾	..	..	..	..	27	41	53	60	63	65	66	68	69	71
2⅞	..	..	..	..	25	39	51	58	61	63	65	67	68	69
3	..	..	..	..	..	37	50	57	60	62	64	65	67	68
3⅛	..	..	..	..	..	35	48	55	58	60	62	64	66	67
3¼	..	..	..	..	..	33	46	54	57	59	61	63	64	66
3⅜	..	..	..	..	..	31	42	52	55	58	60	62	63	65
3½	..	..	..	..	..	29	40	51	54	56	58	60	62	63
3⅝	..	..	..	..	..	27	39	49	52	55	57	59	61	62
3¾	..	..	..	..	..	26	37	48	51	54	56	58	60	61
3⅞	..	..	..	..	..	..	36	46	50	52	55	57	58	60
4	..	..	..	..	..	..	34	45	48	51	53	55	57	59
4⅛	..	..	..	..	..	..	33	42	47	50	52	54	56	58
4¼	..	..	..	..	..	..	31	40	46	48	51	53	55	57
4⅜	..	..	..	..	..	..	29	39	43	47	50	52	54	55
4½	..	..	..	..	..	..	28	37	41	46	48	51	53	54
4⅝	..	..	..	..	..	..	27	36	40	45	47	50	51	53
4¾	..	..	..	..	..	..	25	35	39	42	46	48	50	52
4⅞	..	..	..	..	..	..	..	34	37	41	45	47	49	51
5	..	..	..	..	..	..	..	32	36	40	42	46	48	50

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[a] See footnote *a* of Table II.

[b] Sizes of knots permitted for a given strength ratio at the edges of wide faces wider than 12 in. in joists and planks are increased only in proportion to the square root of the increase of width of the face. Below these limits, sizes are proportioned to the square of the remaining width of the face after the width of the knot is subtracted.

TABLE V.—STRENGTH RATIOS CORRESPONDING TO VARIOUS COMBINATIONS OF SIZE OF SHAKE OR CHECK AND THICKNESSES AT END OF PIECE.[a, b]

Note.—This table covers beams and stringers or joists and planks with shakes or checks in middle one-half of height. Strength ratios for stress in horizontal shear.

Size of Shake or Check, in.	Green Lumber										Seasoned Lumber									
	Percentage Strength Ratio When Nominal End Thickness of Piece in Inches is:										Percentage Strength Ratio When Nominal End Thickness of Piece in Inches is:									
	2	3	4	5	6	8	10	12	14	16	2	3	4	5	6	8	10	12	14	16
¼	90	93	95	96	96	97	98	98	98	99	100	100	100	100	100	100	100	100	100	100
⅜	83	89	92	93	94	96	97	97	98	98	94	100	100	100	100	100	100	100	100	100
½	77	85	88	91	92	94	95	96	97	97	87	95	100	100	100	100	100	100	100	100
⅝	71	81	85	88	90	93	94	95	96	96	80	91	96	99	100	100	100	100	100	100
¾	65	76	82	86	88	91	93	94	95	96	73	86	93	97	99	100	100	100	100	100
⅞	58	72	79	83	86	90	92	93	94	95	66	81	89	94	97	100	100	100	100	100
1	52	68	76	81	84	88	90	92	93	94	59	77	85	91	94	99	100	100	100	100
1⅛	..	64	73	78	82	86	89	91	92	93	52	72	82	88	92	97	100	100	100	100
1¼	..	60	70	76	80	85	88	90	91	92	..	67	78	85	90	95	99	100	100	100
1⅜	..	56	67	73	78	83	87	89	90	92	..	62	75	82	87	94	97	100	100	100
1½	..	51	63	71	76	82	85	88	90	91	..	58	71	80	85	92	96	99	100	100
1⅝	..	..	60	68	74	80	84	87	89	90	..	53	68	77	83	90	95	98	100	100
1¾	..	..	57	66	71	79	83	86	88	89	..	48	64	74	80	88	93	96	99	100
1⅞	..	..	54	63	69	77	82	85	87	88	..	..	61	71	78	87	92	95	98	100
2	..	..	51	61	67	75	80	84	86	88	..	..	57	68	76	85	90	94	97	99
2⅛	..	..	48	58	65	74	79	83	85	87	..	..	54	66	73	83	89	93	96	98
2¼	..	..	..	56	63	72	78	82	84	86	..	..	50	63	71	81	88	92	95	97
2⅜	..	..	..	53	61	71	77	81	83	85	..	..	..	60	69	80	86	91	94	96
2½	..	..	..	51	59	69	75	79	82	85	..	..	..	57	66	78	85	89	93	95
2⅝	..	..	..	48	57	68	74	78	81	84	..	..	..	54	64	76	83	88	92	94
2¾	..	..	..	..	55	66	73	77	81	83	..	..	..	52	62	74	82	87	91	93
2⅞	..	..	..	..	53	65	72	76	80	82	..	..	..	49	59	73	81	86	90	93
3[b]	..	..	..	..	51	63	70	75	79	81	..	..	..	..	57	71	79	85	89	92
3¼	..	..	..	..	..	60	68	73	77	80	..	..	..	..	52	67	76	82	87	90
3½	..	..	..	..	..	57	65	71	75	78	..	..	..	..	48	64	74	80	85	88
3¾	..	..	..	..	..	54	63	69	73	77	..	..	..	..	..	60	71	78	83	86
4	..	..	..	..	..	50	60	67	72	75	..	..	..	..	..	57	68	75	81	85
4¼	..	..	..	..	..	..	58	65	70	74	..	..	..	..	..	53	65	73	79	83
4½	..	..	..	..	..	..	55	63	68	72	..	..	..	..	..	50	62	71	77	81
4¾	..	..	..	..	..	..	53	61	66	71	..	..	..	..	..	..	59	68	75	79
5	..	..	..	..	..	..	50	59	65	69	..	..	..	..	..	..	57	66	73	78
5¼	..	..	..	..	..	..	..	57	63	67	..	..	..	..	..	..	54	64	71	76
5½	..	..	..	..	..	..	..	54	61	66	..	..	..	..	..	..	51	61	69	74
5¾	..	..	..	..	..	..	..	52	59	64	..	..	..	..	..	..	..	59	67	72
6	..	..	..	..	..	..	..	50	57	63	..	..	..	..	..	..	..	57	65	71
6¼	..	..	..	..	..	..	..	..	56	61	..	..	..	..	..	..	..	54	63	69
6½	..	..	..	..	..	..	..	..	54	60	..	..	..	..	..	..	..	52	61	67
6¾	..	..	..	..	..	..	..	..	52	58	..	..	..	..	..	..	..	50	59	65
7	..	..	..	..	..	..	..	..	50	56	..	..	..	..	..	..	..	..	57	64
7¼	..	..	..	..	..	..	..	..	..	55	..	..	..	..	..	..	..	..	55	62
7½	..	..	..	..	..	..	..	..	..	53	..	..	..	..	..	..	..	..	53	60
7¾	..	..	..	..	..	..	..	..	..	52	..	..	..	..	..	..	..	..	51	58

TABLE V.—*Continued*

Size of Shake or Check, in.	Green Lumber										Seasoned Lumber									
	Percentage Strength Ratio When Nominal End Thickness of Piece in Inches is:										Percentage Strength Ratio When Nominal End Thickness of Piece in Inches is:									
	2	3	4	5	6	8	10	12	14	16	2	3	4	5	6	8	10	12	14	16
8.............	..	..	..	..	..	..	..	..	..	50	..	..	..	..	..	..	..	..	..	56
8¼.............	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	55
8½.............	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	53
8¾.............	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	51
9.............	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	49

[a] In tabulating the sizes of shakes or checks, the rule used in approximating decimals by common fractions with ⅛-in. intervals has the effect of subtracting $\frac{1}{24}$ in. from the size of each shake or check. For example, the strength ratios listed for a 3½-in. shake or check are those that actually would obtain for a size of $3\frac{11}{24}$ in. In view of the allowance thus introduced and the fact that nominal instead of actual widths of face are used, the strength ratios in this table should be taken as maximum values.

[b] Ratios for sizes of shake or check other than those listed between 3 and 9 in. can be found by interpolation.

planks whose description provides:

(*1*) Slope of grain not steeper than 1 in 14.

(*2*) Permissible knots as given in columns 2, 4, and 6 of Table VI.

(*3*) Shakes, checks, and splits not more than one fourth of the thickness of the end if graded green, nor more than one third of the thickness of the end if graded seasoned.

(*b*) Provision (*1*), according to Table I, gives a maximum strength ratio of 74 per cent for stress in extreme fiber in bending or tension parallel to grain and 87 per cent in compression parallel to grain.

(*c*) The values in columns 3, 5, and 7 of Table VI are found from Tables II, IV, and III, respectively, and show the strength ratios for stress in extreme fiber in bending corresponding to the various knot sizes and widths of face. Strength ratios in compression parallel to grain are affected only by the largest knots and are found in column 7 of Table VI.

(*d*) The ratings for shakes, checks, and splits in green and seasoned material can be calculated from the equations of Section 27, or can be found by looking up examples in Table V. By the first method, it is found that the strength ratio in horizontal shear is 75 per cent, green or seasoned.

(*e*) Considering Paragraphs (*b*), (*c*), and (*d*), it is found that the minimum strength ratio for extreme fiber in bending or tension parallel to grain is 67 per cent, for compression parallel to grain the minimum strength ratio is 67 per cent, and for horizontal shear, it is 75

TABLE VI.—PERMISSIBLE KNOTS.

Nominal Width of Face, in.	Knots					
	Within Middle Third of Length				Along Center Line of Wide Face	
	On Narrow Face		At Edge of Wide Face			
	Size, in.	Strength Ratio from Table II, per cent	Size, in.	Strength Ratio from Table IV, per cent	Size, in.	Strength Ratio from Table III, per cent
1	2	3	4	5	6	7
2....	⅝	71	...	...	...	...
3....	1	68	...	...	...	...
4....	1¼	70	¾	68	1¼	70
6....	...	...	1	71	2	67
8....	...	...	1⅜	69	2⅝	67
10....	...	...	1¾	69	3¼	68
12....	...	...	2⅛	68	3¾	69
14....	...	...	2⅛	70	3⅞	70
16....	...	...	2½	68	4⅝	67

per cent. If the material is seasoned and is to be used continuously dry as in most covered structures, the strength ratios in bending, tension, and compression are $67 + \frac{67 - 50}{2} = 75\frac{1}{2}$ per cent. The working stress in compression is subject to an additional increase of 10 per cent for drying, equivalent to a strength ratio of 83 per cent in that property.

GENERAL REQUIREMENTS FOR STRESS GRADES

Size Standards

29. (*a*) The minimum dressed[4] sizes (unseasoned) of structural lumber are as follows:

(*1*) *Joists and Planks.*—Nominal thicknesses, 2 in. to but not including 5 in.; nominal widths, 4 in. or more; standard thicknesses S1S, S2S, or S4S, $\frac{3}{8}$ in. less than nominal; standard widths S1E, S2E, or S4S, 4 in. nominal, $3\frac{5}{8}$ in. dressed; 6 in. or wider, $\frac{1}{2}$ in. less than nominal.

(*2*) *Beams and Stringers.*—Nominal thicknesses 5 in. or more; nominal widths, 8 in. or more; standard sizes, S1S, S1E, S2S, or S4S, $\frac{1}{2}$ in. less than nominal thicknesses or widths.

(*3*) *Posts and Timbers.*—Nominal sizes 5 by 5 in. and larger; standard sizes, S1S, S1E, S2S, or S4S, $\frac{1}{2}$-in. less than nominal.

(*4*) *Boards.*—Nominal thickness 1 in.; standard thickness S1S, S2S, or S4S, 25/32 in.; standard widths, S1E or S2E, 2 to 4 in., $\frac{3}{8}$ in. less than nominal, and 6 in. or more wide, $\frac{1}{2}$ in. less than nominal.

(*b*) Rough lumber shall be sawed to full nominal dimensions, except that occasional slight variation in sawing is permissible. No shipment shall contain more than 20 per cent of pieces of minimum dimension due to such variation in sawing. In any one shipment, at least 80 per cent of the pieces shall be of full nominal dimensions, and the remainder not more than $\frac{1}{16}$ in. scant.

General Quality of Lumber

30. (*a*) No piece of exceptionally light weight shall be permitted.

(*b*) All lumber shall be well manufactured.

(*c*) Only sound wood, free from any form of decay, shall be permitted, unless otherwise specified. Unsound knots and limited amounts of decay in its early stages are permitted in some of the lower stress-rated grades used for light framing. Sapwood decay is not admitted under this provision. Limited amounts of bluestain in sapwood may be admitted in some grades.

Slope of Grain

31. (*a*) Slope of grain is measured and limited at whatever point in the length of a structural timber that shows the greatest slope. It shall be measured over a distance sufficiently great to define the general slope, disregarding such short local deviations as those around knots.

(*b*) In 1-in. boards, or similar small sizes of lumber, a general slope of grain anywhere in the length shall not pass completely through the thickness of the piece in a longitudinal distance in inches less than the number expressing the specified permissible slope. Where such a slope varies across the width of the board, its average may be taken.

NOTE 1.—Local deviations of grain from sawing of crooked trees or associated with knots just outside the board may have a serious effect on the strength of small pieces. This additional restriction in 1-in. boards is therefore necessary. A similar restriction is made in other small stress-graded pieces such as ladder rails.

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[4] Dressing is specified as surfacing on one side (S1S), two sides (S2S), one edge (S1E), two edges (S2E), or both sides and both edges (S4S).

Holes

32. Knotholes and holes from causes other than knots shall be measured and limited as provided for knots.

Cluster Knots

33. Cluster knots shall not be permitted.

Knots in Joists and Planks

34. (*a*) The size of a knot on a narrow face of a joist or plank is its width between lines enclosing the knot and parallel to the edges of the piece (Fig. 2). A narrow-face knot that appears also in the wide face of a side-cut joist (but does not contain the intersection of those faces) is measured and graded only on the wide face.

(*b*) The size of a knot on a wide face is the average of its largest and smallest diameters; the size of a spike knot is the average of its length and its greatest width (Fig. 2).

(*c*) A corner knot or a knot extending entirely across the width of a face in a side-cut joist is measured on its end or ends between lines parallel to the edges of the piece and is graded with respect to the face on which it is measured (Fig. 2). A corner knot in a joist containing the pith is measured either by its width on the narrow face between lines parallel to the edge, or by its smallest diameter on the wide face, whichever is more restrictive (Fig. 2). If a corner knot appears also on an opposite face, its limitation there as well as on the corner is necessary. In wide faces 3 in. or less in width, any knot in the middle third of the length shall be considered as being at the edge of the wide face.

(*d*) The sizes of knots on narrow faces and at the edges of wide faces may increase proportionately from the size permitted in the middle one third of the length to twice that size at the ends of the piece, except that the size of no knot shall exceed the size permitted at the center of the wide face. The sizes of knots on wide faces may be increased proportionately from the size permitted at the edge to the size permitted at the center line.

(*e*) The sum of the sizes of all knots in any 6 in. of length of the piece shall not exceed twice the size of the largest permitted knot. Two or more knots of maximum or near maximum permissible size shall not be allowed in the same 6 in. of length on a face. Any combination of knots which, in the judgment of the lumber grader, will unfit the piece for its intended use, shall not be admitted.

(*f*) In the grading and measurement of knots in joists and planks of square cross-section 4 by 4 in. or smaller, each of the four faces is graded as a narrow face. In larger squares, each face is graded as a wide face.

Knots in Beams and Stringers

35. (*a*) The size of a knot on a narrow face of a beam or stringer is its width between lines enclosing the knot and parallel to the edges of the piece (Fig. 3), except that when a knot on a narrow face of a side-cut piece extends into the adjacent one fourth of the width of a wide face, its least dimension is taken as its size.

(*b*) The size of a knot on the wide face is measured by its smallest diameter (Fig. 3). A knot at the edge of a wide face is limited to the same size as a knot on a narrow face, but is measured by its smallest diameter.

(*c*) A corner knot in a beam or stringer containing the pith is measured either by its width on the narrow face between lines parallel to the edges or by its smallest diameter on the wide face, whichever is greater (Fig. 3).

(*d*) The sizes of knots on narrow faces and at the edges of wide faces may be increased proportionately from the size permitted in the middle one third of the length to twice that size at the ends of the piece, except that the size of no knot shall exceed the size permitted at the center of the wide face. The size of knots on wide faces may be increased proportionately from the size permitted at the edge to the size permitted at the center line.

(*e*) The sum of the sizes of all knots within the middle one half of the length of a face, in a beam 20 ft or less in length, when measured as specified for the face under consideration, shall not exceed four times the size of the largest knot allowed on that face. This restriction in a beam longer than 20 ft shall apply to any 10 ft of length within the middle one half of the length.

Knots in Posts and Timbers

36. (*a*) The size of a knot on any face of a post or timber is taken as the diameter of a round knot, the lesser of the two diameters of an oval knot, or the greatest diameter perpendicular to the length of a spike knot. A corner knot is measured wherever the measurement will represent the true diameter of the branch causing the knot. In compression members with greater width than thickness, the sizes of knots in both the narrow and the wide faces are allowed up to the size permitted in the wide face.

(*b*) The sum of the sizes of all knots in any 6 in. of length of a post or timber shall not exceed twice the size of the largest permitted knot. Two or more knots of maximum or near maximum permissible size shall not be allowed in the same 6 in. of length on a face.

Knots in 1-in. Boards

37. Knots in 1-in. boards are measured by the average of the widths on the two opposite faces, each width being taken between lines parallel to the edges of the board. Narrow-face knots are not measured on the narrow face, since they appear also in one or both wide faces. A knot appearing in both wide faces is considered to be only one knot. Sizes of knots are limited to the sizes permitted in the center of the wide faces of joists and planks (Table III). The sum of the sizes of all knots in any 6 in. of length shall not exceed the size of the largest allowable knot.

Shakes, Checks, and Splits in Joists and Planks, Beams and Stringers, and Boards

38. (*a*) Shakes are measured at the ends of the piece, and the size permitted is determined by the thickness of the piece. The size of a shake is the distance between lines enclosing the shake and parallel to the wide faces of the piece.

(*b*) Checks and splits are limited to the same nominal dimensions as shakes (Table V) but are measured differently. The size of a check is its average depth of penetration into the piece measured from and perpendicular to the surface of the wide face. The size of an end split is one third of its average length.

(*c*) The grading of any combination of shakes, checks, and splits in the middle one half of the height is based on the grader's judgment of the probable effects of seasoning or loading in service on the combination. Where a combination of two checks in opposite faces, a check and a split, a check and a shake, or a split and a shake may later become a single horizontal shear plane, the sum of the sizes in the combination is restricted to the allowable size of shake. Where such a combination is not additive in this way, only the largest single characteristic is considered.

(*d*) Where 2-in. dimension is to be used in light building construction in which the shear stress is not critical, a more liberal provision on end splits may be made. In such material, the length of an end split is limited to one and one-half times the width of the wide face in a grade with a shear strength ratio of 50 per cent, or three-quarters of the width of the wide face in a grade with a shear strength ratio of 75 per cent. Other grades are in proportion.

(*e*) Provisions described in Paragraphs (*a*) to (*c*) are applicable to 1-in. boards if used where shear strength is important. The alternate provision given in Paragraph (*d*) may be applied to 1-in. boards stress-graded for light building construction.

Shakes, Checks, and Splits in Posts and Timbers

39. Shakes and side checks shall be limited in all grades to one third the width of unseasoned lumber or one half the width of dry lumber. The length of an end split shall not exceed one and one-half times the allowable size of a shake or a side check, but this length may be permitted in addition to the allowable shake or side check. Measurement shall be made in the same way as in joists and planks and beams and stringers. The width may be considered to be either of the two dimensions of a rectangular cross-section. No combination of shakes, checks, or splits that will prevent the piece from acting as a unit under compressive loads shall be admitted.

Requirements for Continuous Spans

40. If joists and planks or beams and stringers are to be used on continuous spans, the restrictions for knots in the middle one third of their length shall be applied to the middle two thirds of the length of pieces continuous on three supports, and to the full length of pieces continuous on four or more supports. Restrictions for shakes or checks shall be applied in the middle half of the height of the piece and for a distance equal to three times the height of the piece (height equals width of wide face) anywhere throughout the length.

OPTIONAL REQUIREMENTS FOR STRESS GRADES

Heartwood Requirements

41. (*a*) When heartwood material is desired, it may be specified in terms of the amount or percentage of heartwood on the girth, or on each face, side, or edge, measured at the point where the greatest amount of sapwood occurs.

(*b*) For all lumber to be pressure-treated, there shall be no heartwood requirement and the amount of sapwood shall not be limited. A requirement of 1-in. minimum thickness of sapwood at the butt end may be made on poles or piles intended for service as round timbers, pressure-treated.

Wane

42. Wane is permissible in all grades, as far as strength properties are concerned, but "free from wane" may be specified when required by appearance, bearing, or other factors of use.

Density (Douglas Fir and Southern Yellow Pine)

43. (*a*) Dense Douglas fir or dense southern yellow pine shall average on one end or the other of each piece not less than six annual rings per inch and one-third or more summerwood (the darker, harder portion of the annual ring) measured on a representative radial line as specified. The contrast in color between springwood and summerwood shall be distinct. Douglas fir and southern yellow pine pieces that average not less than four annual rings per inch shall be accepted as dense if they average one-half or more summerwood.

(*b*) Measurement of density shall be made in such a way as to insure that the measured radial line is representative. Measurement shall be made over a continuous length of 3 in. or as nearly 3 in. as is available. The length shall be centrally located in side-cut pieces. In pieces containing the pith, the measurement may exclude an inner portion of the radius amounting to approximately one-quarter of the least dimension of the piece.

Close Grain (Douglas Fir, Southern Yellow Pine, and Redwood)

44. (*a*) Close-grained Douglas fir or close-grained southern yellow pine shall average on one end or the other of each piece not less than 6 nor more than 30 annual rings per inch, measured on a representative radial line as specified. Pieces averaging at least 5 or more than 30 rings per inch shall be accepted as close-grained if the measurement shows one-third or more summerwood.

(*b*) Close-grained redwood shall average in each piece not less than 8 nor more than 40 annual rings per inch.

(*c*) Measurement for close grain shall be made in such a way as to insure that the measured radial line is representative. Measurement shall be made over a continuous length of 3 in. or as nearly 3 in. as is available. The length shall be centrally located in side-cut pieces. In pieces containing the pith, the measurement may exclude an inner portion of the radius amounting to approximately one-quarter of the least dimension of the piece.

Medium Grain

45. (*a*) Medium-grained Douglas fir or southern yellow pine lumber shall average on one end or the other of each piece not less than four annual rings per inch, measured on a representative radial line as specified.

(*b*) Measurement for medium grain shall be made in such a way as to insure that the measured radial line is representative. Measurement shall be made over a continuous length of 3 in. or as nearly 3 in. as is available. The length shall be centrally located in side-cut pieces. In pieces containing the pith, the measurement may exclude an inner portion of the radius amounting to approximately one quarter of the least dimension of the piece.

EXAMPLES OF STRUCTURAL GRADING PROVISIONS

General Considerations

46. (*a*) The grading provisions shown here are not intended to establish grades for purchase, but rather to show how stress grading principles are applied. For this reason, the permitted sizes of knots or other characteristics are left blank, with reference to the tables from which sizes appropriate to the desired grade can be taken. Detailed grading rules for commercial stress grades which serve as purchase specifications are established and published by agencies[5] which formulate and maintain such rules and maintain inspection facilities covering the various species.

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[5] Such agencies in the United States include the following: California Redwood Assn., 576 Sacramento St., San Francisco 11, Calif.; National Hardwood Lumber Assn.. 59 E. Van Buren St., Chicago 5, Ill.; Northeastern Lumber Mfrs. Assn., 271 Madison Ave., New York 16, N. Y.; Northern Hemlock and Hardwood Mfrs., Assn., Oshkosh, Wis.; Southern Cypress Mfrs. Assn., Barnett National Bank Bldg., Jacksonville 2, Fla.; Southern Pine Inspection Bureau, National Bank of Commerce Bldg., New Orleans, La.; West Coast Lumber Inspection Bureau, 1410 S. W. Morrison St., Portland 5, Ore.; Western Pine Assn., Yeon Bldg., Portland 4, Ore.

In Canada, grading rules for commercial stress grades are established on a similar basis by agencies including the following: British Columbia Lumber Mfrs. Assn., 302 Forest Industries Bldg., Vancouver, B. C., Canada; Canadian Standards Assn., 3010 National Research Bldg., Ottawa, Ontario, Canada; Alberta Forest Products Assn., Edmonton Credit Bldg., Edmonton, Alberta, Canada; Canadian Lumbermen's Assn., 27 Goulbourn Ave., Ottawa, Ontario, Canada.

(*b*) Requirements shown are those essential for the assignment of a working stress. Additional provisions for the sake of appearance or other desired qualities may be added when required.

(*c*) It is desirable in setting up a system of stress grades to select grade strength ratios that, when applied to basic stresses, will give the same working stress values to species of different inherent strengths. A low grade in a species with a high basic stress may thus carry the same working stress value as a higher grade in a species of lower basic stress. A system of standardized or preferred values for working stresses may be used as a guide. Such preferred values may be in an arithmetic progression, such as 2000, 1800, 1600, 1400 psi, etc. A geometric progression, in which each value has the same ratio to the next above or below, is particularly useful in this connection, since basic stresses, strength ratios, and working stresses can all be given values from the same series. In this way, grading rules and strength ratios can be standardized among species at the same time that working stresses are standardized.

TABLE VII.—MAXIMUM PERMISSIBLE SIZES OF KNOTS.

Nominal Width of Face, in.	Permissible Size of Knots, max, in.	
	On Narrow Face or at Edge of Wide Face, Middle Third of Length	At Center Line of Wide Face
2	On narrow face — For permissible sizes, see Table II.	...
3		...
4		...
4	At edge of wide face — For permissible sizes, see Table IV.	For permissible sizes, see Table III.
6		
8		
10		
12		
14		
16		

Requirements for Joists and Planks, Grade —

NOTE 2.—The requirements in Section 47 are for pieces to be used over simple spans, with load applied to either the wide or the narrow face. See Section 40 for modified requirements for continuous spans. The requirements also permit the assignment of working stresses in longitudinal tension or compression.

47. (*a*) The strength ratios for this grade are — per cent for stress in extreme fiber in bending or in tension parallel to grain, — per cent for stress in compression parallel to grain, and — per cent for stress in horizontal shear. These strength ratios are for lumber that is to be used continuously dry, as in most covered structures.

(*b*) No piece of exceptionally light weight is permitted. All material shall be free from incipient or advanced decay, red heart, dote, or rot.

NOTE 3.—See Section 30 (*c*) for certain exceptions to the requirements on decay.

(*c*) Slope of grain shall not be steeper than ——————. (For permissible slope of grain, see Table I.) Slope of grain shall be measured over a distance sufficiently great to determine the general slope, disregarding slight local deviations.

(*d*) Maximum permissible sizes of knots are shown in the schedule in Table VII.

(*e*) Measurements of knots shall be in accordance with the provisions of Section 34 (*a*), (*b*), and (*c*).

(*f*) The sizes of knots on narrow faces and at the edges of wide faces may be increased proportionately from the size permitted in the middle third of the length to twice that size at the ends, except that the size of no knot shall exceed the size permitted at the center of the wide face. The size of knots on wide faces may be increased proportionately from the size permitted at the edge to the size permitted at the center line.

(*g*) The sum of the sizes of all knots in any 6 in. of length of the piece shall not exceed twice the size of the largest permitted single knot. Two or more knots of maximum or near maximum permissible size shall not be allowed in the same 6 in. of length on a face. Cluster knots are prohibited. Any combination of knots which, in the judgment of the grader, will unfit the piece for its intended use, shall not be admitted.

(*h*) Knotholes and holes from causes other than knots are measured and limited as provided for knots.

(*i*) The size of shakes, checks, and splits shall not exceed the following values: (For permissible sizes for dry material, see values for seasoned lumber in Table V. Sizes may be expressed in inches for each thickness of piece or may be expressed as a fraction of the thickness. An alternative method for use with 2-in. dimension used in light framing is given in Section 38).

(*j*) Measurement of shakes, checks, and splits shall be in accordance with the provisions of Section 38.

Requirements for Beams and Stringers, Grade —

NOTE 4.—The requirements in Section 48 are for pieces to be used over simple spans, with the load applied to the narrow face.

48. (*a*) The strength ratios for this grade are — per cent for stress in extreme fiber in bending, and — per cent for stress in horizontal shear. These strength ratios are the same for green and for seasoned lumber.

(*b*) No piece of exceptionally light weight is permitted. All material shall be free from incipient or advanced decay, red heart, dote, or rot.

(*c*) Slope of grain shall not be steeper than ————. (For permissible slope of grain, see column 2 of Table I.) Slope of grain shall be measured over a distance sufficiently great to determine the general slope, disregarding slight local deviations.

(*d*) Maximum permissible sizes of knots are shown in the following schedule:

Nominal Width of Face, in.	Permissible Size of Knots, max, in.	
	On Narrow Face, Middle Third of Length	At Center Line of Wide Face
5.....	For permissible sizes, see Table II.	For permissible sizes, see Table III.
6.....		
8.....		
10.....		
12.....		
14.....		
16.....		
18.....		
20.....		

(*e*) Measurement of knots shall be in accordance with the provisions of Section 35 (*a*, *b*, and *c*). Knots at edges of wide faces are limited to the same sizes as on the narrow faces of the same piece.

(*f*) The sizes of knots on narrow faces and at the edges of wide faces may be increased proportionately from the size permitted in the middle third of the length to twice that size at the ends, except that the size of no knot shall exceed the size permitted at the center of the wide face. The size of knots on wide faces may be increased proportionately from the size permitted at the edge to the size permitted at the center line.

(*g*) The sum of the sizes of all knots within the middle one half of the length of a face in a beam 20 ft or less in length, when measured as specified for the face under consideration, shall not exceed four times the size of the largest knot allowed on that face. Cluster knots are prohibited. Any combination of knots which, in the judgment of the grader, will unfit the piece for its intended use, shall not be admitted.

(*h*) Knotholes and holes from causes other than knots are measured and limited as provided for knots.

(*i*) The sizes of shakes, checks, and splits shall not exceed the following values: (Permissible sizes of shakes and splits in green material are given in Table V. Checks result from seasoning and are not graded in green material. Permissible sizes of shakes, checks, and splits in seasoned material are given in Table V. Sizes may be expressed in inches for each thickness of piece or may be expressed as a fraction of the thickness).

(*j*) Measurement of shakes, checks, and splits shall be in accordance with the provisions of Section 38.

Requirements for Posts and Timbers, Grade —

49. (*a*) The strength ratio of this grade is — per cent for stress in compression parallel to grain.

(*b*) No piece of exceptionally light weight is permitted. All material shall be free from incipient or advanced decay, red heart, dote, or rot.

(*c*) Slope of grain shall not be steeper than ————. (For permissible slope of grain, see column 3 of Table I.) Slope of grain shall be measured over a distance sufficiently great to determine the general slope, disregarding slight local deviations.

(*d*) Maximum permissible sizes of knots are shown in the following schedule:

Nominal Width of Face, in.	Maximum Permissible Size of Knots at Any Point in Any Face, in.
5	For permissible sizes, see Table III.
6	
8	
10	
12	
14	
16	
18	
20	

(*e*) Measurement of knots shall be in accordance with the provisions of Section 36 (*a*).

(*f*) The sum of the sizes of all knots in any 6 in. of length of a post or timber shall not exceed twice the size of the largest permitted knot. Two or more knots of maximum permissible size shall not be allowed in the same 6 in. of length on a face. Cluster knots are prohibited. Any combination of knots which, in the judgment of the grader, will unfit the piece for its intended use, shall not be admitted.

(*g*) Knotholes and holes from causes other than knots are measured and limited as provided for knots.

Requirements for Boards, Grade —

50. (*a*) The strength ratio of this grade is — per cent for stress in tension parallel to grain and — per cent for stress in compression parallel to grain.

(*b*) No piece of exceptionally light weight is permitted. All material shall be free from incipient or advanced decay, red heart, dote, or rot.

(*c*) Slope of grain shall not be steeper than ————. (For permissible slope of grain, use either column 2 or column 3 of Table I, but note that the specified slope gives a different strength ratio in tension than in compression.) A general slope of grain anywhere in the length shall not pass completely through the thickness of the board in a longitudinal distance less than — in. (The number of inches is the same as the number expressing the permissible slope of grain.) Measurement of slope of grain shall be in accordance with the provisions of Section 31 (*b*).

(*d*) The sizes of knots shall not exceed the following values: (For permissible sizes, see Table III. Knot sizes may be tabulated for each width of board, or the size may be specified as an allowable fraction of the cross section).

(*e*) Knots are measured by the average of the widths on the two opposite faces, each width being taken between lines parallel to the edges of the board. Knots are not measured in narrow faces. The sum of the sizes of all knots in any 6 in. of length shall not exceed the size of the largest allowable knot. A knot appearing on both wide faces is considered to be only one knot. Cluster knots are prohibited.

(*f*) Knotholes and holes from causes other than knots are measured and limited as provided for knots.

(*g*) The size of a shake, check, or split shall not exceed — in. (value for 1-in. thickness from Table V). Measurement of shakes, checks, and splits shall be in accordance with the provisions of Section 38 (*e*).

NOTE 5.—The requirement of Section 50 (*g*) may be omitted where shear strength is unimportant.

BASIC STRESSES

RECOMMENDED BASIC STRESS VALUES

Table of Stresses

51. (*a*) Table VIII gives recommended basic stresses for clear lumber of the more common domestic structural species. These are applicable to long-time loading; and since factors of safety are included in their derivation, they require only application of the grade strength ratio to become working stresses for design. Adjustments for duration of load or other factors are discussed in Sections 60 to 67 of these methods.

(*b*) Basic stress values in bending, tension parallel to grain, compression perpendicular to grain, and compression parallel to grain for dense Douglas fir and southern yellow pine in Table VIII have been increased by about one sixth of the corresponding values for medium-grained material. Basic stress values in the same properties for close-grained Douglas fir (Coast type) and redwood have been increased by about one fifteenth of the corresponding values for material not so classified. Density, close grain, and medium grain are defined in Sections 43, 44, and 45 of these methods.

(*c*) Values for compression parallel to grain in Table VIII apply to posts, columns, or struts whose unsupported length does not exceed eleven times the least dimension of the cross section.

PRINCIPLES IN THE DETERMINATION OF BASIC STRESSES

Application

52. Basic stresses for structural lumber are applicable to both green and dry material. They are, therefore, applicable to lumber that is exposed to the weather. While small clear specimens of wood may show for some properties appreciable increase in strength with seasoning, it has been found that in structural lumber the gain in strength from drying is partially or completely offset by the development of drying defects. Some increase in strength for seasoning is recognized in 1- and 2-in. lumber, in the higher grades of joists and planks, and in all grades of compression members. The conditions under which allowance may be made for benefit from drying are mentioned in Section 61 of these methods.

Factors Involved

53. Basic stresses involve consideration of a series of factors intended to represent the various circumstances that affect the adequacy of structural lumber. Some of these factors are well understood or can be accurately evaluated from available data; others are definable only in terms of engineering judgment and experience. For example, the range in strength of clear wood can be evaluated from a considerable body of test data, but the magnitude of the factor of safety that should be used in any given instance can be established only by engineering judgment. It is, therefore, not possible to arrive at working stresses by any mathematical analysis alone. Experience and judgment, backed by pertinent test data, must be employed to formulate basic stresses that are applicable to certain representative conditions. With these representative conditions defined, means may be suggested by which the working stresses can be adjusted by the engineer to meet other circumstances of design that may be encountered.

Loading Assumptions

54. (*a*) The basic stresses recommended are based on the premise that the design loads are realistic, but they do not provide for overload except as this may be related to the factor of safety involved. It is contemplated that negligence in overloading will be controlled by suitable supervision of the structure in service.

(*b*) In many constructions there is a repetition of load-carrying members and a continuity of loading from one to another, so that deficiency in the one may be compensated by possible over-adequacy of its neighbor. On the other hand, many members, such as columns and girders, are not given that protection, and basic stresses applicable to all grades are premised on the assumption of the individual timber carrying its load.

Range of Test Values

55. Basic stresses reflect the results of investigation of the lower range of representative test values, but are not necessarily limited by the lowest value obtained in the tests. Engineers accept this principle as a proper approach in determining working stresses.

Factor of Safety

56. It is recognized that no factor of safety, whatever its magnitude, insures absolute safety. The basic stresses assume normal variability of material, competent design, good fabrication, reliable grading, and adequate supervision. Statistical studies of the interaction of all the factors of strength and use that affect the safety of structural timbers indicate that the most probable value of the true factor of safety in service is about $2\frac{1}{2}$, that 95 per cent of the timbers have factors of safety of $1\frac{1}{4}$ or more, while a few have factors of safety as high as 5.

Design and Use

57. Experience has shown that structural lumber is an engineering material, susceptible to rational design by engineering principles. These stresses are premised on the condition that they will be used in such a design. Engineering design calls for stress-graded material, and there should be adequate provision to insure that stress grades are obtained and properly used. Lastly, wood, like any other structural material, must have adequate maintenance if these stresses are to be used. It must be protected from decay or other deteriorating agencies, and joints and fastenings must be kept tight. In short, an engineering design and proper use are requisite.

TABLE VIII.—BASIC STRESSES FOR CLEAR LUMBER UNDER LONG-TIME SERVICE AT FULL DESIGN LOAD.[a]

For Use in Determining Working Stresses According to Grade of Lumber and Other Applicable Factors.

Commercial Names for Lumber[b]	Extreme Fiber in Bending or Tension Parallel to Grain, psi	Horizontal Shear, max, psi	Compression Perpendicular to Grain, psi	Compression Parallel to Grain, psi ($L/d = 11$ or Less)	Modulus of Elasticity in Bending, psi
1	2	3	4	5	6
		SOFTWOODS			
Baldcypress (cypress)	1900	150	220	1450	1 200 000
Cedar:					
Alaska	1600	130	185	1050	1 200 000
Atlantic white (southern white cedar) and northern white	1100	100	130	750	800 000
Port Orford	1600	130	185	1200	1 500 000
Western red cedar	1300	120	145	950	1 000 000
Douglas fir:					
Coast type, medium-grained	2200	130	235	1450	1 600 000
Coast type, close-grained	2350	130	250	1550	1 600 000
Rocky Mountain type	1600	120	205	1050	1 200 000
All types, dense	2550	130	275	1700	1 600 000
Fir:					
Balsam	1300	100	110	950	1 000 000
California red, grand, noble, and white	1600	100	220	950	1 100 000
Hemlock:					
Eastern	1600	100	220	950	1 100 000
Western (West Coast hemlock)	1900	110	220	1200	1 400 000
Larch, western	2200	130	235	1450	1 500 000
Pine:					
Eastern white (northern white), ponderosa, sugar, and western white (Idaho white)	1300	120	185	1000	1 000 000
Jack	1600	120	160	1050	1 100 000
Lodgepole	1300	90	160	950	1 000 000
Red (Norway pine)	1600	120	160	1050	1 200 000
Southern yellow, medium-grained	2200	160	235	1450	1 600 000
Southern yellow, dense	2550	160	275	1700	1 600 000
Redwood	1750	100	185	1350	1 200 000
Close-grained	1900	100	195	1450	1 200 000
Spruce:					
Engelmann	1100	100	130	800	1 000 000
Red, white, and Sitka	1600	120	185	1050	1 200 000
Tamarack	1750	140	220	1350	1 300 000
		HARDWOODS			
Ash:					
Black	1450	130	220	850	1 100 000
Commercial white	2050	185	365	1450	1 500 000
Aspen, bigtooth and quaking	1300	100	110	800	800 000
Beech, American	2200	185	365	1600	1 600 000
Birch, sweet and yellow	2200	185	365	1600	1 600 000
Cottonwood, eastern	1100	90	110	800	1 000 000
Elm:					
American and slippery (soft elm)	1600	150	185	1050	1 200 000
Rock	2200	185	365	1600	1 300 000
Hickory, true and pecan	2800	205	440	2000	1 800 000

TABLE VIII.—*Continued.*

Commercial Names for Lumber	Extreme Fiber in Bending or Tension Parallel to Grain, psi	Horizontal Shear, max, psi	Compression Perpendicular to Grain, psi	Compression Parallel to Grain, psi (L/d = 11 or Less)	Modulus of Elasticity in Bending, psi
1	2	3	4	5	6
HARDWOODS					
Maple, black and sugar (hard maple)....	2200	185	365	1600	1 600 000
Oak, commercial red and white.........	2050	185	365	1350	1 500 000
Sweetgum (gum, red gum, sap gum).....	1600	150	220	1050	1 200 000
Tupelo, black (black gum) and water....	1600	150	220	1050	1 200 000
Yellow-poplar (poplar)................	1450	130	160	1050	1 200 000

[a] These stresses are based on the strength of green lumber and are applicable, with certain adjustments, to lumber of any degree of seasoning, or lumber used under any conditions of duration of load.

[b] In accordance with the Nomenclature of Domestic Hardwoods and Softwoods (ASTM Designation: D 1165),[6] the commercial names for lumber represent recommended commercial practice.

Responsibility of Designer

58. It is assumed to be the final responsibility of the designing engineer to relate design assumptions and working stresses, and to make modifications of design stresses to fit a particular use, subject to the requirements of any applicable building code.

APPLICATION OF STRESSES

GENERAL CONSIDERATIONS

Application of Grade Strength Ratios

59. The basic stress for a species (Table VIII) is multiplied by the strength ratio appropriate for a stress grade to give the working stress for structural design with that grade of the species. Grade strength ratios are determined from the size or amount of the strength-reducing characteristics permitted by the rules of the grade. Strength ratios for use in evaluating working stresses from the basic stresses in bending, tension parallel to grain, and compression parallel to grain (columns 2 and 5, Table VIII) are obtained from Tables I, II, III, and IV. Strength ratios for use in evaluating working stresses from the basic stresses in shear (column 3, Table VIII) are obtained from Table V. Strength in compression perpendicular to grain and modulus of elasticity (columns 4 and 6, Table VIII), are but little affected by grade, and a strength ratio of 100 per cent is assumed for all grades. In other words, the basic stress is also the working value for use in design.

MODIFICATIONS OF STRESS

Summary of Factors

60. The principal modifications made in working stresses for various causes are summarized in Table IX.

Seasoning Effects

61. (*a*) The strength of clear wood increases as its moisture content decreases below the fiber saturation point, but in sawed structural lumber this increase of strength is largely offset by the development of seasoning defects, such as checks or honeycombing. Basic stress values in Table VIII are suitable for green lumber or lumber that is completely submerged so that no decay hazard exists. Certain increases above these values can be made for lumber that will be continu-

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[6] See p. 175.

ously dry in use, such as in most covered structures.

(*b*) No increase for drying is made in bending stresses for beams and stringers or other lumber more than 4 in. thick.

(*c*) The effect of seasoning on the strength in bending or in tension parallel to grain of joists and planks varies with the grade, the greatest improvement being in the higher grades. For lumber 2 to 4 in. in nominal thickness (joists and planks) to be used where continuously dry, as in most covered structures, strength ratios in bending, tension, or compression parallel to grain are increased by half of their excess over 50 per cent. For example, if the green strength ratio is 68 per cent, the dry strength ratio is $68 + \frac{68 - 50}{2} = 77$ per cent. Since many joists remain continuously dry in use, it is common practice to take advantage of the increase in strength from drying by increasing permissible sizes of knots or other characteristics rather than by increasing the working stresses; where this is done, the working stress may require reduction if the material is to be used under wet conditions.

TABLE IX.—MODIFICATION OF WORKING STRESSES BY GRADE AND USE FACTORS.[a, b]

Kind of Working Stress	Size Classification	Working Stress Modified by:				
		Grade	Rate of Growth	Density	Seasoning	Duration of Load
1	2	3	4	5	6	7
Extreme fiber in bending and tension parallel to grain	1-in. boards	yes	yes	yes	yes	yes
	Joists and planks	yes	yes	yes	yes[c]	yes
	Beams and stringers	yes	yes	yes	no	yes
Horizontal shear	all sizes	yes	no	no	yes[c]	yes
Compression perpendicular to grain	all sizes	no	yes	yes	yes	yes
Compression parallel to grain	all sizes	yes	yes	yes	yes[c]	yes
Modulus of elasticity	all sizes	no	no	no	yes	no[d]

[a] Modification for grade (column 3) is accomplished by application of the grade strength ratio. Modifications for rate of growth and density (columns 4 and 5) are shown under the appropriate species in the basic stresses of Table VIII. Modifications for seasoning and duration of load (columns 6 and 7), are to be made by the designer to fit the particular conditions for which the design is made.

[b] See Section 63 for a discussion of possible adjustments of working stress for decay hazard.

[c] Modification for seasoning in joists and planks may be accomplished either by liberalizing grade limitations or by increasing working stress.

[d] If deflection under long-time load must be limited, it is common practice to provide for the long-time increase of deformation by using one half of the modulus of elasticity value in Table VIII in calculating the stiffness of the member. Modulus of elasticity, when considered as a measure of the basic stiffness of the wood, is not affected by duration of load.

(*d*) Drying defects have less effect on compressive than on bending strength, and the increase from drying is significant in all grades of compression members. An increase of 10 per cent above the values of Table VIII for columns of all lengths may be taken for drying regardless of size or grade. If existing grades of joists and planks have a bonus for drying as described in Paragraph (*c*) a 10 per cent increase may be made in addition to that bonus. Care must be taken in applying this increase to the thicker columns, that the column is sufficiently seasoned before full load is applied.

(*e*) Table V indicates the increased sizes of shakes, checks, and splits permitted in seasoned as compared to green lumber.

(*f*) Working stresses in compression perpendicular to grain may be increased by 50 per cent above the values in Table VIII for lumber that will be continuously dry in use.

(*g*) An increase of 10 per cent in modulus of elasticity from the values of Table VIII may be taken for dry lumber.

(*h*) Working stresses for all grades of 1- or 2-in. (nominal) lumber that is dressed at 15 per cent or lower moisture content and is fabricated and used under conditions where that moisture content is not exceeded, may be increased from the values of Table VIII by one quarter in bending or tension parallel to grain, one eighth in horizontal shear, one half in compression perpendicular to grain, three eighths in compression parallel to grain, and one tenth in modulus of elasticity. These increases are not in addition to, but take the place of the increases described in Paragraphs (*c*) to (*g*).

(*i*) Although drying results in increases of strength in many structural timbers, designers of timber structures should consider that the size may be significantly reduced by the shrinkage that usually accompanies drying. Increases of working stress for drying are based on strength properties related to the actual dimensions of the dry wood.

Duration of Load

62. (*a*) Stress values in Table VIII (excepting those for modulus of elasticity in column 6) are applicable to the condition of long-time loading. Wood possesses the favorable characteristic of ability to absorb overloads of considerable magnitude for short periods, or smaller overloads for longer periods. Advantage can be taken of this characteristic in many structural designs. Figure 5 shows the relation of working stress to duration of maximum load.

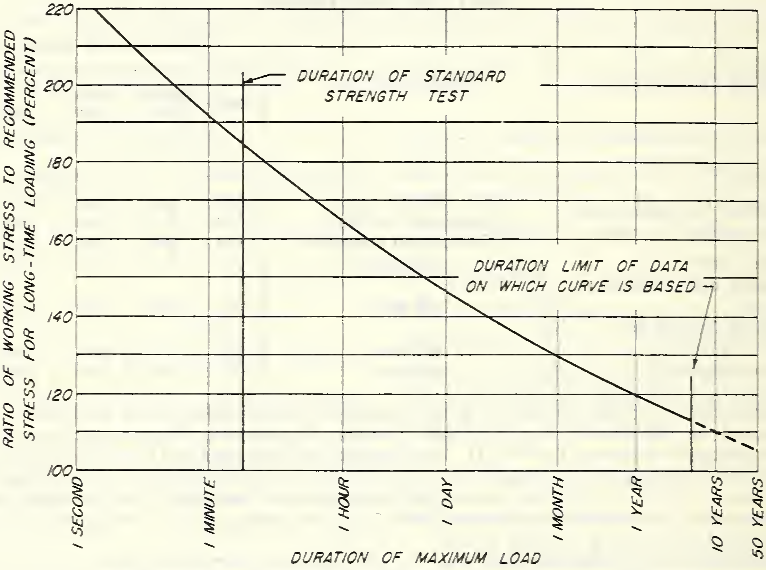

Fig. 5.—Relation of Working Stress to Duration of Load.

(*b*) The curve shown in Fig. 5 is an approximate representation of data mainly from tests in bending of Douglas fir and Sitka spruce. A limited amount of supporting data indicate that the same relationship holds in other species and other properties including tension and compression parallel or perpendicular to grain, horizontal shear, and bearing on mechanical fastenings. Modulus of elasticity is discussed in Paragraph (*f*) of this Section. In view of the limited scope of the supporting data, the curve is not exact and precise interpolations from it should not be made.

(*c*) Long-time loading tests have shown that repeated loads separated by periods of rest have a cumulative effect, but that the sum of all loaded periods before failure will equal or exceed the duration of continuous load at the same stress level. The studies indicate that cumulative effects from repeated loads are decreased as the ratio of loaded time to unloaded time is decreased.

(*d*) In applying a stress increase for conditions of less than full duration of maximum load, the safe stress for the permanent part of the combined loading must not be exceeded. Where the assumed loading conditions involve some infrequent load at high level and a more frequent load at a lower level, care should be taken to see that working stresses and sizes of structural members are safe for each one of the assumed load levels. It is possible for sizes of wood members to be governed by the permanent load or some other load below maximum load level.

(*e*) Working stress values may be used without allowance for occasional impacts up to 100 per cent of the static load, provided that the resulting sizes of structural members are safe also for the static loadings.

(*f*) Modulus of elasticity, when used as a measure of deflection or deformation, does not increase with time. When used, however, in calculating safe loads on long columns, a reduction factor of three, applied to the modulus of elasticity in Table VIII, gives a safe value for long-time loading. Since the buckling of a long column is sensitive to the duration of load, a somewhat smaller reduction factor can be taken for short-time than for long-time loading. A convenient way to do this is to use the increases of Fig. 5 for long-column loads calculated with a reduction factor of 3 from the values in Table VIII.

(*g*) Wood under continuing load takes on a continuing increment of deformation known as plastic flow or yield, usually very slow but persistent over long periods of time. Deflection of this nature occurring in timbers acting as beams is sometimes known as "set" or "sag." This increase of deformation with time may become as much as the initial deformation without endangering the safety of the timber. This effect is of importance only where the long-continued load is at or near the maximum design level. It is necessary, where deformation or deflection under long periods of loading must be limited in amount, to provide extra stiffness. This can be done by doubling any dead or long-time loads when calculating deformation, by setting an initial deformation limit at half the long-time deformation limit, or by using one half of the recommended value of modulus of elasticity in calculating the immediate deformation. In any case, it is to be understood that the recommended values for modulus of elasticity will give the immediate deflection of a beam, and that this will increase under long-continued load. The increase may be somewhat greater where the timber is subjected to varying temperature and moisture conditions than where the conditions are uniform.

(*h*) A study of the continuing increase of deformation may be used to evaluate the safety of heavily stressed timbers. A deformation continuing to increase, but at a decreasing rate, even after a very long period of time, does not presage failure. On the other hand, deformation continuing to increase at a uniform rate may be a danger signal, and when the increase begins to accelerate, failure is imminent.

(*i*) Normal aging effects in old timbers may include seasoning, weathering, or chemical change, in addition to the effects from duration of load. In the absence of deteriorating influences such as decay, these additional aging effects are structurally unimportant. Strength tests of old timbers from a number of sources have shown that wood does not deteriorate appreciably in strength or stiffness from age alone for periods of 100 years or more. Old lumber may be appraised with respect to its species, grade, and condition. Where the condition is good, and no evidence of decay or other specific deteriorating influence appears, old lumber may be given the same working stress values as those for new lumber of equivalent species and grade.

Decay Hazards

63. (*a*) Since there is no satisfactory way of numerically appraising the effect of decay on the strength of wood, decay is excluded from most structural grades. No working stress can be assigned with assurance to timber containing decay. Decay confined to knots and not present in wood surrounding them is permitted in some structural grades. Limited decay of pocket-type is also permitted in the lowest dimension grades of some species. Structural lumber exposed to the hazard of decay should be inspected at frequent and regular intervals. If decay is detected in or near highly stressed areas, the member should be replaced. Special attention given to such features as drainage and ventilation will help reduce or eliminate the necessity of removing lumber because of decay. Treated wood or the heartwood of species of high natural decay resistance should be used to prolong the life and eliminate the need for expensive replacements wherever conditions are favorable to decay.

(*b*) When untreated wood is used under conditions favorable to decay, some loss of strength may occur before the decay is detected. A reduction of design stress may be in order so that the structure may safely carry its design loads for the time until decay is detected and the affected material can be removed. The amount of reduction is a matter of choice for the structural designer. A general range from a few per cent up to 25 per cent is adequate. Stiffness is affected less than strength, and shock resistance is affected most.

(*c*) Reductions of working stress for decay hazard are intended to provide only temporary protection until decay is detected and repairs or replacements can be made. It should be emphasized again that there is no safe working stress for decayed wood.

Preservative Treatment

64. (*a*) It may be necessary in establishing allowable working stresses for preservative treated timber to take into account possible reductions in strength that may result from the high temperatures and pressures used for conditioning of wood at a high moisture content under approved methods of treatment. Results of tests of treated timber show reduction in stress in extreme fiber in bending and in compression perpendicular to grain ranging from a few per cent up to 25 per cent, depending on the treating conditions. Compression parallel to grain is affected less and the modulus of elasticity very little. The effect on resistance to horizontal shear can be estimated by inspection for shakes and checks after treatment.

(*b*) These reductions in strength can be minimized by restricting temperatures, heating periods, and pressures as much as is consistent in obtaining the absorption and penetration required for proper treatment.

(*c*) Where structural design with treated timbers is on a conservative basis, such as that indicated for decay hazards in Section 63 (*b*), any initial loss of strength from treatment is balanced against the progressive loss of strength of untreated wood with the incidence of decay.

Temperature

65. Basic stress values in Table VIII are applicable to lumber used under ordinary ranges of temperature. Occasional exposures up to about 150 F and longer exposures up to about 125 F are provided for. Special allowance should be made for lumber subjected to abnormally high temperatures, particularly for long periods of time.

Bearing Areas

66. Basic stresses in Table VIII are unit values that generally do not vary with the area loaded. In compression perpendicular to grain, however, there is a supporting action of fibers adjoining the loaded area that has the effect of increasing allowable unit stresses on small bearing areas. The values in Table VIII for compression perpendicular to grain apply to bearings 6 in. or more in length located anywhere in the length of a structural member and to bearings of any length located at the ends of beams or joists. For bearings shorter than 6 in. or for round bearing areas (as under washers) of the same diameters, if located 3 in. or more from the end of a member, the stresses may be increased in accordance with the following factors:

Length or Diameter of Bearing Area, in.	Factor of Increase
½	1.75
1	1.38
1½	1.25
2	1.19
3	1.13
4	1.10
6 or more	1.00

Special Conditions

67. Recommended stress values are suitable for the usual conditions of design. While they contain a factor of safety applicable to ordinary conditions, it is recognized that the possibility of failure of an individual timber is not entirely excluded. This bears consideration in connection with the consequences of failure. In the first place, it is understood that failure means the inability of an individual timber to continue to carry its load, and does not necessarily imply collapse of a structure. Further, it is significant of wood that warning of overload or distress can generally be detected in time for remedial action before danger occurs. The designing engineer will weigh these considerations against the economics of the specific project with which he is concerned. If consequences of failure of an individual timber are likely to be especially serious, he may reduce working stresses and thereby reduce the hazard of failure. Conversely, in situations where failure of a timber can result only in property damage of limited extent, and where repair can easily be made, he may be justified in economizing through the use of stresses higher than those of Table VIII. Attention is called in this connection to the fact that analysis of probabilities shows that the probability of failure increases or decreases more rapidly than would be indicated by the percentage increase or decrease of stress.

EXAMPLE OF WORKING STRESS CALCULATION

Joists and Planks

68. (*a*) Assume a grade of joists and planks with grade strength ratios of 60 per cent in bending, tension, and compression parallel to grain, and 75 per cent in shear. No increases for drying have been made, except that the strength

ratio in shear is based on the grading of dry material. Assume the grade to be used under permanent loading in a continuously dry situation. The basic stresses are 2200 psi in bending or tension, 130 psi in shear, and 1450 psi in compression parallel to grain. Calculate the working stresses.

(*b*) Since long-time loading is contemplated, no modification of stress for duration of load is made.

(*c*) The strength ratio in bending or tension is increased for drying by half its excess over 50 per cent, to give a working stress of 2200 × 65% = 1430 psi.

(*d*) The working stress in compression parallel to grain receives the same increase of strength ratio plus an additional 10 per cent. It is thus calculated as 1450 × 65% × 1.1 = 1040 psi (approximately).

(*e*) The working stress in shear is 130 × 75% = 100 psi (approximately).

Standard Specifications for

ROUND TIMBER PILES[1]

ASTM Designation: D 25 – 58

Adopted, 1955; Revised, 1958.[2]

This Standard of the American Society for Testing Materials is issued under the fixed designation D 25; the final number indicates the year of original adoption as standard or, in the case of revision, the year of last revision.

Scope

1. These specifications cover round timber piles to be used untreated or treated with standard preservatives. Contracts that do not specify whether piles are to be treated or untreated shall be construed as requiring piles for treatment (Note 1).

Note 1.—The purpose of these specifications is to provide satisfactory piles for driving to bearing values that are related to the supporting power of the soil, rather than to the ultimate strength of the pile. Where round timber piles are used in structural design to sustain loads or forces approaching the maximum safe working strength of structural lumber, they should be designed in accordance with the principles of the Methods for Establishing Structural Grades of Lumber (ASTM Designation: D 245).[3] Sawed lumber used as piles may be selected in accordance with the same principles where the use requires a specific strength value.

Species of Wood

2. Piles may be of any species of wood which will withstand driving and will support the loads imposed. The purchaser shall specify the species of wood desired (Note 2).

Note 2.—Commonly used species include cedars, cypress, Douglas-fir, elm, hemlock, western larch, maple, oaks, pines, spruces, and tamarack.

Use Classification

3. Timber piles are classified in these specifications under three general divisions according to the use intended, as follows:

(*a*) *Class A*.—Piles suitable for use in heavy railway bridges or other heavy framed construction. The minimum diameter of butt permits the use of load-bearing timber caps 14 in. in width.

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[1] Under the standardization procedure of the Society, these specifications are under the jurisdiction of the ASTM Committee D-7 on Wood.

[2] Prior to their present adoption as standard, these specifications were published as tentative from 1915 to 1920. They were adopted in 1920, published as standard from 1920 to 1930, but withdrawn and republished as tentative from 1930 to 1937, being revised in 1934 and 1935. They were again adopted in 1937, and published as standard from 1937 to 1952. They were revised and reverted to tentative in 1952 and were published as tentative from 1952 to 1955, being revised in 1953 and 1954.

[3] See p. 184.

(*b*) *Class B.*—Piles suitable for use in docks, wharves, bridges, building or other foundations, and general construction. The minimum diameter of butt permits the use of load-bearing timber caps 12 in. in width (Note 3).

NOTE 3.—Smaller sizes than those stipulated for Class B piles in Section 6 and Table I may be specified by the purchaser, where piles of Class B quality are desired for use with light bearing values or in special cases, as with concrete caps.

(*c*) *Class C.*—Piles suitable for use in foundations which will always be completely submerged, for cofferdams, falsework, or light construction.

REQUIREMENTS FOR ALL CLASSES OF PILES

General Quality

4. (*a*) Piles shall be of sound wood, free from decay, red heart, or insect attack, except as herein provided. The butt end of cedar and cypress piles may have a pipe or stump rot hole not more than $1\frac{1}{2}$ in. in diameter. Cypress piles may have peck aggregating not more than the hole limitation. Southern pine piles may have unsound knots not exceeding half the permitted size of a sound knot, provided that the unsoundness extends to not more than a $1\frac{1}{2}$-in. depth, and that the adjacent areas of the trunk are not affected. Piles having sound turpentine scars undamaged by insects may be accepted.

(*b*) Piles shall be cut above the ground swell, and shall have a continuous taper from the point of butt measurement to the tip.

(*c*) Sizes of knots shall be as specified in Section 13 or 18. Knot clusters are prohibited (Note 4). Requirements for spacing of knots shall be applied at the centers of the knots considered.

NOTE 4.—A knot cluster is two or more knots grouped together, the fibers of the wood being deflected around the entire unit. A group of single knots, with fibers deflected around each knot separately, is not a cluster, even though the knots may be in close proximity.

Lengths

5. All piles shall be furnished cut to any of the following lengths as specified: 16 to 40 ft in multiples of 2 ft; over 40 ft, in multiples of 5 ft. Individual piles may vary from the length specified as much as ±1 ft in piles shorter than 40 ft, and ±2 ft in piles 40 ft or longer. The average length of all piles of a specified length in each shipment shall be not less than the length specified.

Circumferences and Diameters

6. (*a*) The circumferences of piles measured under the bark shall have minimum and maximum values as given in Table I, except that not more than 10 per cent of the piles in any shipment may have circumferences 2 in. less than the tabulated minimum values. Requirements for tip circumference of piles that are longer than the required length may be applied at the tip end of the required length.

(*b*) The ratio of the maximum to the minimum diameter at the butt of any pile shall not exceed 1.2.

Heartwood

7. If high heartwood content is required in untreated piles, it shall be specified, and the diameter of the heartwood shall be not less than eight tenths of the diameter of the pile at the butt.

Sapwood

8. Wood piles for preservative treatment shall have not less than 1 in. of sapwood at the butt end.

Cutting and Trimming

9. (*a*) Butts and tips of piles shall be sawed square with the axis of the pile.

(*b*) All knots and limbs shall be

trimmed or smoothly cut flush with the surface of the pile, except that knots may be hand-trimmed flush with the surface of the swell surrounding the knot.

(*c*) Rough-peeled piles require the complete removal of all outer bark.

(*d*) Unpeeled piles require no bark removal.

TABLE I.—CIRCUMFERENCES AND DIAMETERS OF TIMBER PILES.

Length, ft	Class A						Class B						Class C					
	3 Ft from Butt				At Tip, min		3 Ft from Butt				At Tip, min		3 Ft from Butt				At Tip, min	
	Min		Max				Min		Max				Min		Max			
	Circumference, in.	Diameter (approx), in.	Circumference, in.	Diameter (approx), in.	Circumference, in.	Diameter (approx), in.	Circumference, in.	Diameter (approx), in.	Circumference, in.	Diameter (approx), in.	Circumference, in.	Diameter (approx), in.	Circumference, in.	Diameter (approx), in.	Circumference, in.	Diameter (approx), in.	Circumference, in.	Diameter (approx), in.
Douglas Fir, Hemlock, Larch, Pine, Spruce, or Tamarack																		
Under 40	44	14	57	18	28	9	38	12	63	20	25	8	38[a]	12[a]	63	20	25	8
40 to 50 incl	44	14	57	18	28	9	38	12	63	20	22	7	38	12	63	20	19	6
55 to 70 incl	44	14	57	18	25	8	41	13	63	20	22	7	38	12	63	20	19	6
75 to 90 incl	44	14	63	20	22	7	41	13	63	20	19	6	38	12	63	20	19	6
Over 90	44	14	63	20	19	6	41	13	63	20	16	5	38	12	63	20	16	5
Oak and Other Hardwoods, Cypress																		
Under 30	44	14	57	18	28	9	38	12	57	18	25	8	38[a]	12[a]	63	20	25	8
30 to 40 incl	44	14	57	18	28	9	41	13	63	20	22	7	38	12	63	20	22	7
Over 40	44	14	57	18	25	8	41	13	63	20	19	6	38	12	63	20	19	6
Cedar																		
Under 30	44	14	69	22	28	9	38	12	69	22	25	8	38[a]	12[a]	69	22	25	8
30 to 40 incl	44	14	69	22	28	9	41	13	69	22	25	8	38	12	69	22	25	8
Over 40	44	14	69	22	25	8	41	13	69	22	22	7	38	12	69	22	22	7

[a] In Class B piles, a minimum circumference of 34 in. or diameter of 11 in. at a point 3 ft from the butt may be specified for lengths of 25 ft and under.

[b] In Class C piles, a minimum circumference of 31 in. or diameter of 10 in. at a point 3 ft from the butt may be specified for lengths of 25 ft and under.

Peeling

10. (*a*) Piles are classified according to the extent of bark removal as clean-peeled, rough-peeled, or unpeeled.

(*b*) Clean-peeled piles require the removal of all outer bark. In addition, at least 80 per cent of the inner bark, well distributed over the surface of the pile, shall be removed. For proper preservative treatment, no strips of inner bark wider than ½-in. shall remain.

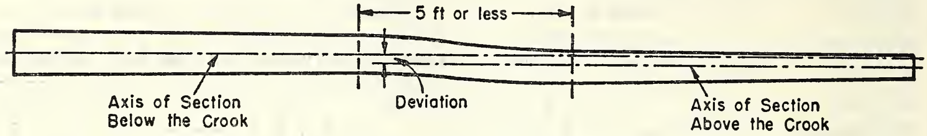
Requirements for Class A or B Piles

Straightness

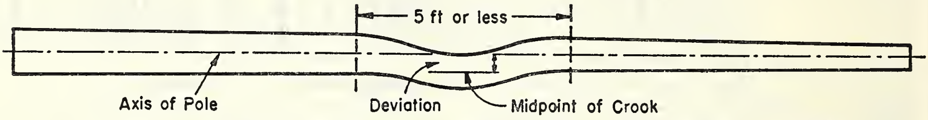
11. (*a*) A straight line from the center of the butt to the center of the tip of Class A or B piles shall lie entirely within the body of the pile (Note 5).

Note 5.—Long piles for driving to lighter bearing values may be bought under a more liberal alternative specification as follows: "A straight line from the center of the butt to the center of the tip may lie partly outside the body of the pile, but the maximum distance between the line and the pile shall not exceed one-half per cent of the length of the pile or 3 in., whichever is smaller."

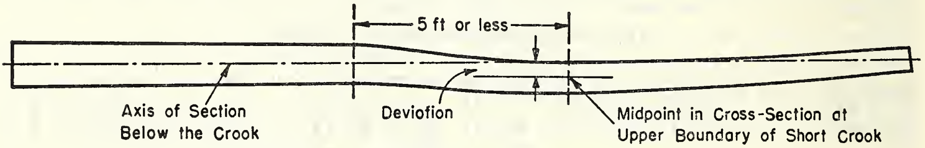
(*b*) Class A or B piles shall be free from short crooks in which the deviation from straightness in any 5 ft of length anywhere exceeds 2½ in. (Fig. 1). Short crooks shall also comply with the requirements for sweep in Paragraph (*a*).



Case 1–Where the Reference Axes are Approximately Parallel



Case 2–Where Axes of Sections Above and Below the Crook Coincide or are Practically Coincident



Case 3–Where Axis of Section Above Short Crook is not Parallel or Coincident with Axis Below the Crook

The three cases shown are typical, and are intended to establish the principle of measuring short crooks. There may be other cases not exactly like those illustrated.

FIG. 1.—Measurement of Short Crook.

Twist of Grain

12. Spiral grain shall not exceed one-half of a complete twist in any 20 ft of length.

Knots

13. Sound knots in Class A or B piles 50 ft or less in length, and in three-quarters of the length from the butt of Class A or B piles longer than 50 ft, shall be no larger than 4 in. or one-third of the diameter of the pile at the point where they occur, whichever is the smaller. Sound knots in the remaining one-quarter of the length of piles longer than 50 ft shall be no larger than 5 in. or one-half of the diameter of the pile at the point where they occur, whichever is the smaller. The size of a knot shall be its diameter measured at right angles to the length of the pile. Unsound knots shall not be permitted, except as specified under Section 4(*a*). Cluster knots are prohibited (Note 4). The sum of sizes of all knots in any foot of length of the pile shall not exceed twice the size of the largest permitted single knot.

Holes

14. Holes less than ½ in. in average

diameter shall be permitted in Class A or B piles, provided the sum of the average diameters of all holes in any square foot of pile surface does not exceed $1\frac{1}{2}$ in.

Splits and Shakes

15. (*a*) Splits in Class A or B piles shall be not longer than the butt diameter.

(*b*) The length of any shake or combination of shakes in the outer half of the radius of the butt of the pile, when measured along the curve of the annual ring, shall not exceed one third of the circumference of the butt of the pile.

REQUIREMENTS FOR CLASS C PILES

Straightness

16. (*a*) A straight line from the center of the butt to the center of the tip of Class C piles may lie partly outside the body of the pile, but the maximum distance between the line and the pile shall not exceed $\frac{1}{2}$ per cent of the length of the pile, or 3 in., whichever is the smaller.

(*b*) Class C piles shall be free from short crooks in which the deviation from straightness in any 5 ft of length anywhere exceeds $2\frac{1}{2}$ in. (Fig. 1). Short crooks shall also comply with the requirements for sweep in Paragraph (*a*).

Twist of Grain

17. Spiral grain shall not exceed one complete twist in any 20 ft of length.

Knots

18. Sound knots in Class C piles shall be no larger than 5 in., or one half the diameter of the pile at the point where they occur, whichever is the smaller. The size of a knot shall be its diameter measured at right angles to the length of the pile. Unsound knots shall not be permitted, except as specified under Section 4(*a*). Cluster knots are prohibited (Note 4). The sum of sizes of all knots in any foot of length of the pile shall not exceed twice the size of the largest permitted single knot.

Holes

19. Holes less than $\frac{1}{2}$ in. in average diameter shall be permitted in Class C piles, provided the sum of the average diameters of all holes in any square foot of pile surface does not exceed 3 in.

Splits and Shakes

20. (*a*) Splits in Class C piles shall be not longer than one and one half times the butt diameter.

(*b*) The length of any shake or combination of shakes in the outer half of the radius of the butt of the pile, when measured along the curve of the annual ring, shall not exceed one half of the circumference of the butt of the pile.

Tentative Specifications for

WOOD PAVING BLOCKS FOR EXPOSED PLATFORMS, PAVEMENTS, DRIVEWAYS, AND INTERIOR FLOORS EXPOSED TO WET AND DRY CONDITIONS[1]

ASTM Designation: D 52 – 58 T

ISSUED, 1958.[2]

These Tentative Specifications have been approved by the sponsoring committee and accepted by the Society in accordance with established procedures, for use pending adoption as standard. Suggestions for Revisions should be addressed to the Society at 1916 Race St., Philadelphia 3, Pa.

Scope

1. These specifications cover creosoted end grain wood paving blocks for exposed platforms, pavements, and other areas exposed to alternately wet and dry conditions. The specifications are divided into two parts, one covering material and the other a recommended practice for installation.

PART I.—MATERIAL

Species of Timber

2. The wood, which shall be treated, shall be southern pine, Douglas fir, oak, gum, or other species mutually agreed upon by the purchaser and the supplier. Only one kind of wood shall be used in any one contract.

Quality of Timber

3. (*a*) The blocks shall be sound and well manufactured, square butted and square edged, and shall be free from unsound, loose or hollow knots, knot holes, and other defects such as shakes, checks, etc., that would be detrimental to the blocks.

(*b*) Blocks manufactured of southern yellow pine or Douglas fir shall average not less than four annual rings per inch measured over a 3-in. portion of a radial line which is representative of the average growth on the cross-section, except that not more than 5 per cent of the pieces in any lot may have three rings per inch.

Size of Blocks

4. The blocks shall be from 5 to 8 in. in length, but the length shall not exceed three times the depth; they shall be 2 to 4 in. in depth parallel to grain. They may be $2\frac{1}{2}$ to 4 in. in width, but on any one area all shall be of uniform width. Permissible variations from the specified dimensions shall not exceed $\frac{1}{16}$ in. in depth and $\frac{1}{8}$ in. in width. In all cases the

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[1] Under the standardization procedure of the Society, these specifications are under the jurisdiction of the ASTM Committee D-7 on Wood.

[2] Revised and reverted to tentative by action of the Society at the Annual Meeting, June, 1958.

Prior to their present publication as tentative, these specifications were published as tentative from 1918 to 1920, being revised in 1920. They were published as standard from 1920 to 1958.

width shall be greater or less than the depth by at least $\frac{1}{4}$ in.

Preservative

5. The preservative used shall be either creosote furnished in accordance with the Specifications for Creosote (ASTM Designation: D 390),[3] or creosote coal-tar solution furnished in accordance with the Specifications for Creosote-Coal Tar Solution (ASTM Designation: D 391).[3]

Preservative Treatment

6. The timber may be green or partially air-seasoned with moisture content not less than 30 per cent and treated with not less than 10 lb of creosote oil per cubic foot of timber by a standard pressure process, with thorough diffusion throughout the sapwood.

Retention of Preservative

7. (*a*) The net retention in any charge shall be not less than 90 per cent of the quantity of preservative that may be specified. The average retention by the wood blocks treated under any contract or order of five charges or more, and the average retention of any five consecutive charges shall be not less than 100 per cent of the quantity specified, except when the character of the wood in any charge makes these requirements impracticable, despite treatment to refusal. In the latter case, allowance shall be made for the difference between the quantities of preservative specified and retained. When the contract or order comprises less than five charges, the average retention shall be not less than 95 per cent of the quantity specified. The amount of preservative retained shall be calculated from readings of working-tank gages or scales, or from weights before and after treatment of loaded trams on suitable track scales with the necessary corrections for changes in moisture content.

(*b*) The amount of preservative retained by the blocks shall be as stipulated in purchase order and in no case shall be less than 10 lb per cu ft of wood in the charge.

(*c*) The volume of preservative shall be calculated on the basis of a temperature of 100 F. Calculations of volume or weight shall be made by the use of temperature or specific gravity factors contained in the Volume and Specific Gravity Correction Tables for Creosote and Coal Tar (ASTM Designation: D 347).[3]

Penetration of Preservative

8. The blocks after treatment shall show satisfactory penetration of the preservative, and in all cases the oil shall be distributed throughout the sapwood. To determine this, at least 25 blocks shall be selected from various parts of each charge and sawed in half perpendicular to the fibers through the center, and if more than one of these blocks show untreated sapwood, the charge shall be retreated. After retreating, the charge shall be again subjected to a similar inspection and rejected if all blocks do not show complete sapwood penetration.

Inspection at Plant

9. All material prescribed in these specifications and processes used in the manufacture of the blocks therefrom shall be subject to inspection, acceptance, or rejection at the plant of the manufacturer, which shall be equipped with all the necessary gages, appliances, and facilities to enable the inspector to satisfy himself that the requirements of the specifications are being fulfilled.

PART II.—RECOMMENDED PRACTICE FOR INSTALLATION

Foundation

10. The concrete foundation shall be

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[3] Appears in this publication, see Contents in Numeric Sequence of ASTM Designations at front of book.

finished to a smooth even surface, exactly the depth below the finished level corresponding to the depth of the block to be used and with sufficient crown to quickly drain off all water from the surface. Care must be taken to see that there are no projections or waves in the concrete that will form an uneven bearing for the blocks.

Bituminous Paint Coat

11. On the thoroughly cleaned and dried concrete base shall be spread a thin uniform coat of hot coal-tar pitch conforming to the requirements specified in Table I. It shall be heated to a temperature of not less than 250 F, and not more than 300 F, and squeegeed or sprayed over the concrete while hot in a thin, uniform coating $\frac{1}{16}$ to $\frac{1}{8}$ in. in thickness.

TABLE I.—REQUIREMENTS FOR COAL-TAR PITCH (HOMOGENEOUS).

	Min	Max
Specific gravity, 25/25 C (77/77 F)	1.22	1.34
Softening Point (Cube-in-Water Method)	135 F (57 C)	155 F (68 C)
Total bitumen soluble in carbon disulfide, per cent	72	85
Distillation:		
Total distillate by weight, 32 to 572 F (0 to 300 C), per cent	...	10
Specific gravity, 100/60 F (38/15.5 C) of total distillate to 572 F (300 C)	1.03	...

Laying Blocks

12. (*a*) The blocks shall be laid on the hardened bituminous paint coat with the grain of the wood vertical, in straight parallel lines without ramming, leaving enough space between the blocks to afford expansion. All joints shall be broken by a lap of at least 1 in. No less than half blocks shall be used except for closures.

(*b*) Against walls, curbs, or other obstructions, a bituminous expansion joint at least 1 in. in width shall be installed. It may be either a premoulded or a poured joint, using the same bitumen used as a filler.

(*c*) After the floor has been cut in, two coats of bituminous binder shall be applied at the highest possible temperature without burning or injuring its consistency, by the use of a squeegee machine. Care must be exercised to work the binder into the joints uniformly and in such a manner as to leave a minimum of this binder on the surface. The light film of bitumen on the surface will wear off readily under traffic.

Methods of Sampling and Testing

13. The coal-tar pitch shall be sampled and the properties as enumerated in these specifications shall be determined in accordance with the following methods of the American Society for Testing Materials:

(*a*) *Sampling.*—Methods of Sampling Bituminous Materials (ASTM Designation: D 140).[4]

(*b*) *Specific Gravity.*—Method of Test for Specific Gravity of Road Oils, Road Tars, Asphalt Cements, and Soft Tar Pitches (ASTM Designation: D 70).[4]

(*c*) *Softening Point.*—Method of Test for Softening Point of Tar Products (Cube-in-Water Method) (ASTM Designation: D 61).[4]

(*d*) *Bitumen Soluble in Carbon Disulfide.*—Method of Test for Bitumen (ASTM Designation: D 4).[4]

(*e*) *Distillation.*—Method of Test for Distillation of Tars and Tar Products (ASTM Designation: D 20).[4]

(*f*) *Specific Gravity of Distillate.*—Method of Test for Specific Gravity, 38/15.5 C, of Creosote Fractions (ASTM Designation: D 369).[3]

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[4] 1958 Book of ASTM Standards, Part 4.

APPROVED AS
AMERICAN STANDARD
BY THE AMERICAN STANDARDS ASSOCIATION
ASA NO.: O10.1-1958
UDC 624.025:691.11

Standard Specifications for
CREOSOTED END-GRAIN WOOD BLOCK FLOORING FOR INTERIOR USE[1]

ASTM Designation: D 1031 – 55

ADOPTED, 1951; REVISED, 1955.[2]

This Standard of the American Society for Testing Materials is issued under the fixed designation D 1031; the final number indicates the year of original adoption as standard or, in the case of revision, the year of last revision.

Scope

1. These specifications cover creosoted end-grain wood block flooring for interior use. The specifications are divided into two parts, one covering material and the other a recommended practice for installation.

PART I.—MATERIAL

Species of Timber

2. The wood, which shall be treated, shall be air-seasoned or kiln-dried southern pine, Douglas fir, Norway pine, oak, or gum. Only one kind of wood shall be used in any one contract.

Quality of Timber

3. (*a*) The blocks shall be sound and well manufactured, square-butted, and square-edged, and shall be free from unsound, loose, or hollow knots, knot holes, and other defects such as shakes, checks, etc., that would be detrimental to the blocks.

(*b*) Blocks manufactured of Norway pine or Douglas fir shall average not less than six annual rings per inch measured over a 3-in. portion of a radial line which is representative of the average growth on the cross-section. Pieces averaging less than six rings to the inch shall be accepted if they contain 50 per cent or more summerwood.

(*c*) Blocks manufactured of southern pine may be specified as:

Dense Grain which shall average not less than six annual rings per inch measured over a 3-in. portion of a radial line which is representative of the average growth on the cross-section. Pieces averaging less than six rings to the inch shall be accepted if they contain 50 per cent or more summerwood.

Medium Grain which shall provide that the blocks laid in the floor shall, in the aggregate, average not less than four annual rings per inch when measured over a 3-in. portion of a radial line which is representative of the average growth on the cross-section. Blocks with two annual rings per inch, or less, shall not be acceptable.

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[1] Under the standardization procedure of the Society, these specifications are under the jurisdiction of the ASTM Committee D-7 on Wood.

[2] Prior to adoption as standard, these specifications were published as tentative from 1949 to 1951.

Size of Blocks

4. The blocks shall be from 5 to 8 in. in length, but the length should not exceed 3 times the depth: they shall be 2 to 4 in. in depth parallel to grain. They may be 2½ to 4 in. in width but on any one floor all shall be of uniform width. Permissible variations from the specified dimensions shall not exceed $\frac{1}{16}$ in. in depth and ⅛ in. in width. In all cases the width shall be greater or less than the depth by at least ¼ in.

Preservative

5. The preservative used shall be either creosote furnished in accordance with the Specifications for Creosote (ASTM Designation: D 390)[3] or creosote coal-tar solution furnished in accordance with the Specifications for Creosote-Coal Tar Solution (ASTM Designation: D 391).[3]

Preservative Treatment

6. The blocks shall be impregnated under pressure by an empty cell process so that the preservative is adequately distributed in the wood.

Retention of Preservative

7. (*a*) The net retention in any charge shall be not less than 90 per cent of the quantity of preservative that may be specified; but the average retention by the wood blocks treated under any contract or order of five charges or more and the average retention of any five consecutive charges shall be not less than 100 per cent of the quantity specified, except when the character of the wood in any charge makes these requirements impracticable, despite treatment to refusal, in which latter case allowance shall be made for the difference between the quantities of preservative specified and retained. When the contract or order comprises less than five charges the average retention shall be not less than 95 per cent of the quantity specified. The amount of preservative retained shall be calculated from readings of working-tank gages or scales, or from weights before and after treatment of loaded trams on suitable track scales with the necessary corrections for changes in moisture content.

(*b*) The amount of preservative retained by the blocks shall be as stipulated in purchaser's orders, and in no case shall be less than 6 lb per cu ft of wood in the charge.

(*c*) The volume of preservative shall be calculated on the basis of a temperature of 100 F. Calculations of volume or weight shall be made by the use of temperature or specific gravity factors contained in the Volume and Specific Gravity Correction Tables for Creosote and Coal Tar (ASTM Designation: D 347).[3]

Penetration of Preservative

8. The blocks after treatment shall show satisfactory penetration of the preservative, and in all cases the oil shall be distributed throughout the sapwood. To determine this, at least 25 blocks shall be selected from various parts of each charge and sawed in half perpendicular to the fibers through the center, and if more than one of these blocks show untreated sapwood, the charge shall be retreated. After retreating, the charge shall be again subjected to a similar inspection and rejected if all blocks do not show complete sapwood penetration.

Handling Blocks After Treatment

9. The blocks shall be shipped in closed cars and be stored under cover

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[3] Appears in this publication, see Contents in Numeric Sequence of ASTM Designations at front of book.

upon arrival on the work and protected from the weather at all times, both before and after being laid.

Inspection at Plant

10. All material prescribed in these specifications and processes used in the manufacture of the blocks therefrom shall be subject to inspection, acceptance, or rejection at the plant of the manufacturer, which shall be equipped with all the necessary gages, appliances, and facilities to enable the inspector to satisfy himself that the requirements of the specifications are being fulfilled.

PART II.—RECOMMENDED PRACTICE FOR INSTALLATION

Foundation

11. The foundation shall be in accordance with the general specifications of the purchaser for concrete building construction and shall be designed of sufficient strength to carry the load to be encountered. The concrete shall be finished to a smooth, even surface parallel to the contour of the finished floor level and exactly the depth below the finished level corresponding to the depth of the block to be used. This may be accomplished by the use of a wooden float or similar device. Care must be taken to see that there are no projections or waves in the concrete that will form an uneven bearing for the blocks.

Bituminous Paint Coat

12. On the thoroughly cleaned and dried concrete base shall be spread a thin uniform coat of hot coal-tar pitch conforming with the specifications in Section 14. It shall be heated to a temperature of not less than 250 F and not more than 300 F and squeegeed or sprayed over the concrete while hot in a thin, uniform coating $\frac{1}{16}$ to $\frac{1}{8}$ in. in thickness.

Laying Blocks

13. (*a*) On the hardened bituminous paint coat the blocks shall be laid with the fiber of the wood vertical in straight parallel lines and rammed both ways to insure tight joints. All joints shall be broken by a lap of at least 1 in. No less than half blocks shall be used except for closures.

(*b*) *Expansion Joints.*—Against the walls on all sides of the floor, as well as around all columns and other obstructions, a bituminous expansion joint 1 in. in width shall be formed by first laying a strip of that width and after removal, filling the space one-half full with the same bitumen used as a filler.

(*c*) *Binding the Joints.*—After the floor has been cut in, two coats of bituminous binder shall be applied at the highest possible temperature without burning or injuring its consistency, by the use of a squeegee machine. Care must be exercised to work the binder into the joints uniformly and in such a manner as to leave a minimum of this binder on the surface. The light film of bitumen on the surface will wear off readily under traffic.

Bitumen

14. The coal-tar pitch shall be homogeneous and shall conform to the following requirements:

	Min	Max
Specific Gravity, 25/25 C (77/77 F)............	1.22	1.34
Softening Point (Cube-in-Water Method)......	135 F (57 C)	155 F (68 C)
Total Bitumen Soluble in Carbon Disulfide, per cent................	72	85
Distillation Test:		
Total Distillate by weight 32 to 572 F (0 to 300 C per cent)............	...	10
Specific Gravity, 100/60 F (38/15.5 C) of Total Distillate to 572 F (300 C).............	1.03	...

Methods of Sampling and Testing

15. The coal-tar pitch shall be sampled and the properties enumerated in Section 14 shall be determined in accordance with the following methods of the American Society For Testing Materials:

(*a*) *Sampling.*—Methods of Sampling Bituminous Materials (ASTM Designation: D 140).[4]

(*b*) *Specific Gravity.*—Method of Test for Specific Gravity of Road Oils, Road Tars, Asphalt Cements, and Soft Tar Pitches (ASTM Designation: D 70).[4]

(*c*) *Softening Point.*—Method of Test for Softening Point of Tar Products (Cube-in-Water Method) (ASTM Designation: D 61).[4]

(*d*) *Bitumen Soluble in Carbon Disulfide.*—Method of Test for Bitumen (ASTM Designation: D 4).[4]

(*e*) *Distillation.*—Method of Test for Distillation of Tars and Tar Products (ASTM Designation: D 20).[4]

(*f*) *Specific Gravity of Distillate.*—Method of Test for Specific Gravity, 38/15.5 C, of Creosote Fractions (ASTM Designation: D 369).[3]

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[4] 1958 Book of ASTM Standards, Part 4.

APPROVED AS
AMERICAN STANDARD
BY THE AMERICAN STANDARDS ASSOCIATION
ASA NO.: O12.1-1958
UDC 691.11.002.23

Tentative Specifications for

MODIFIED WOOD[1]

ASTM Designation: D 1324 - 57 T

Issued, 1954; Revised, 1957.[2]

These Tentative Specifications have been approved by the sponsoring committee and accepted by the Society in accordance with established procedures, for use pending adoption as standard. Suggestions for revisions should be addressed to the Society at 1916 Race St., Philadelphia 3, Pa.

Scope

1. These specifications cover the material known as modified wood. They are intended to be applicable to wood in the form of solid lumber or veneer (Note 1), or an assembly of lumber or veneer or both, the properties of which have been changed by physical or chemical methods (Note 2). These specifications are not intended to cover those products to which preservatives have been added for the primary purpose of enabling the wood to resist decay and those products to which chemicals have been added for the primary purpose of improving the fire-resistant properties of wood.

Note 1.—For the purpose of these specifications, veneer is considered to be a thin layer or sheet of wood under 5/16 in. in thickness. Layers or sheets of wood 5/16 in. or over in thickness are considered to be lumber.

Note 2.—Modified woods have been growing steadily in importance because of the unusual properties and beauty of the finished product. The properties and even the appearance of the modified wood are largely dependent on the actual physical and chemical methods used in manufacture. An almost infinite number of products are possible. For example, the density of material produced by compression can be varied from that of the normal wood to a specific gravity of almost 1.40, which is about the density of wood substance itself. Because of these possible variations, the specifications which follow are general rather than specific in nature. Specifications for a specific type of product must be based on the actual needs of the user and should be developed jointly by the user and the producer.

Some of the types of modified wood that have been developed are briefly described in the Appendix to these specifications.

Basis of Purchase

2. The purchaser shall specify in the inquiry, contract, and order, the density range and type of material desired and any exceptions, modifications, or agreements with regard to the provisions of these specifications.

Species of Wood

3. Any species of wood may be used in the manufacture of modified wood. The species to be used shall be specified by the purchaser.

Defects

4. Material that would adversely af-

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[1] Under the standardization procedure of the Society, these specifications are under the jurisdiction of the ASTM Committee D-7 on Wood.

[2] Revision accepted by the Society at the Annual Meeting, June, 1957.

fect the strength or appearance of the completed product shall not be used. Veneer or lumber shall, therefore, be free of decay, wane, shakes, open splits, loose knots, worm holes, knot holes, or other holes or openings. Veneer shall be tightly cut, with slope of grain not steeper than 1 in 5. Permissible slope of grain in lumber shall not exceed 1 in 10.

Veneer Thickness

5. Veneers used in the construction of any one panel shall be of the same nominal thickness, which shall not exceed 5⁄16 in.

Lumber Thickness

6. Modified wood made from lumber shall conform to the detailed requirements of the purchaser.

Impregnation

7. Phenol formaldehyde resin or equivalent shall be used in those products requiring resin impregnation, unless otherwise agreed upon by the purchaser and producer.

Fabrication

8. Modified wood manufactured from veneer shall be either parallel or cross-laminated, as specified by the purchaser. Veneer shall be free of patching or inlay of any kind, but edge joints parallel to the grain to make up pieces of required width shall be permitted, provided that (*1*) no individual piece is less than one fourth the built-up width, (*2*) there shall be not more than two joints per piece, (*3*) the edges shall be joined straight and square, (*4*) the joints shall be free of any gaps or chipped edges, and (*5*) there shall be no joints in the veneer at right angles to the grain.

Methods of Test

9. (*a*) The properties of modified wood shall be determined in accordance with the Methods of Testing Veneer, Plywood, and Other Glued Veneer Constructions (ASTM Designation: D 805),[3] or as described in Section 10 of these specifications.

(*b*) Tests of primary importance in evaluating the properties of modified wood are the following:

(*1*) Static bending,

(*2*) Hardness,

(*3*) Swelling and recovery of compressed wood products due to moisture absorption,

(*4*) Moisture content and specific gravity, and

(*5*) Toughness or other suitable impact test.

Hardness Test

10. (*a*) *Scope.*—The wide range of densities possible in the manufacture of modified woods makes difficult the selection of a single hardness test method satisfactory for all types of material. The modified ball hardness test described in the Methods of Testing Small Clear Specimens of Timber (ASTM Designation: D 143),[3] has been found satisfactory for the less dense modified woods. The Rockwell hardness test described in the Methods of Testing Veneer, Plywood, and Other Glued Veneer Constructions (ASTM Designation: D 805),[3] may be used for material of medium density. The hardness-penetration test described in the following Paragraphs (*b*) to (*f*) has found general acceptance in the industry and can be used successfully for determining the hardness of modified woods varying in density from very light to those of maximum density.

(*b*) *Test Specimen.*—The test specimen shall be a minimum of 2 in. in width and 6 in. in length, and equal to the thickness of the material.

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[3] Appears in this publication, see Contents in Numeric Sequence of ASTM Designations at front of book.

NOTE 3.—When the hardness of a thin material is required, it may be necessary to build up the thickness of the test specimen by placing several layers of the same material under the test specimen.

(*c*) *Apparatus:*

(*1*) *Testing Machine.*—The testing machine shall be of the constant-rate-of crosshead movement type and of suitable capacity.

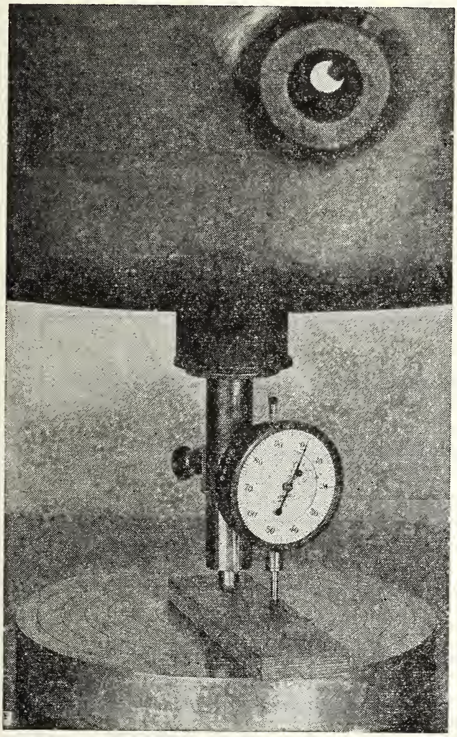

FIG. 1.—Apparatus for Hardness-Penetration Test.

(*2*) *Penetrating Tool.*—The penetrating tool (see Fig. 1) shall be identical with that specified in Section 84 of Methods D 143, except that the collar for determining one-half depth penetration shall be removed. This tool shall have a 0.444-in. diameter (1 sq cm projected area) penetrating ball.

(*3*) *Dial Gage.*—A dial gage (see Fig. 1) reading to 0.001 in. penetration shall be used.

(*d*) *Procedure:*

(*1*) Mount the dial page on the penetrating tool in such a manner (see Fig. 1) that the depth of penetration can be determined, and mount the penetrating tool on the testing machine. Make simultaneous readings of load and penetration, at least 10 points or equivalent plotted data, at sufficient intervals to permit the determination of a straight-line relationship. Make at least two such determinations on each specimen.

(*2*) Make all penetrations far enough from the edge to prevent splitting or chipping of the specimen.

(*e*) *Speed of Testing.*—The load shall be applied to the specimen throughout the test by a uniform motion of the move able head of the testing machine at a rate of 0.02 (±0.005 in.) per min.

(*f*) *Test Data and Report.*—The hardness of the material shall be reported as the load to cause an arbitrarily selected depth of penetration or as a hardness modulus calculated as follows:

$$H_m = \frac{P}{2\pi r h} = 0.717\,\frac{P}{h}$$

where:

H_m = load per unit of spherical area of penetration expressed in pounds per square inch,

r = radius of penetration ball (0.222 in.),

P = arbitrarily selected load in pounds within linear portion of test data, and

h = depth of penetration in inches at the selected load.

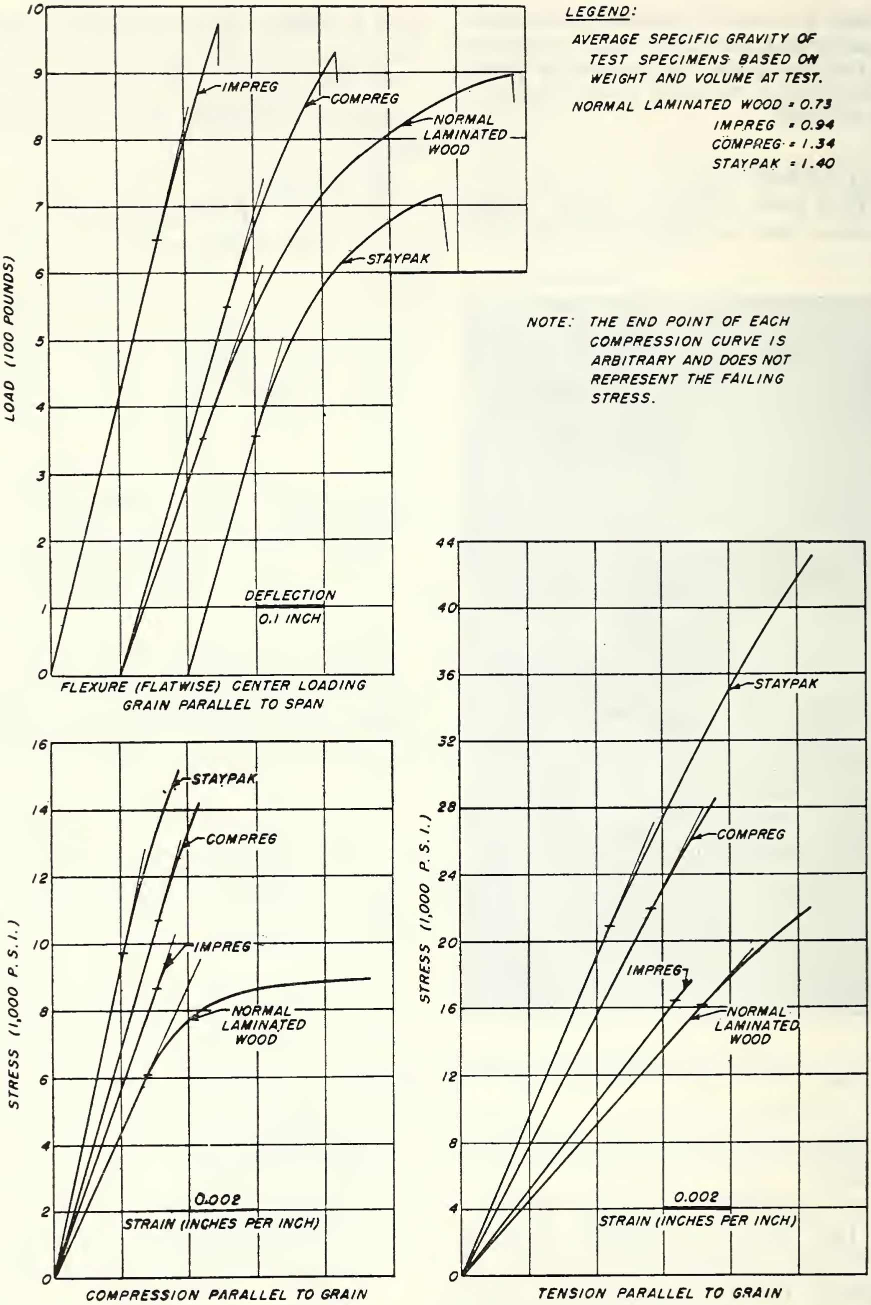

FIG. 2.—Typical Flexure Load-Deflection Curves, and Tensile and Compressive Stress-Strain Curves for Parallel-Laminated Modified Yellow Birch Veneer. The Short Horizontal Line on Curves Indicates Stress or Load at Proportional Limit.

30-54

APPENDIX

Some of the types of modified wood which have been developed are briefly described below. Names used are those applied to the material by the Forest Products Laboratory, Madison, Wis., during development work. These products are now manufactured and sold under a variety of trade names.

Typical flexure load-deflection curves, and tensile and compressive stress-strain curves for parallel-laminated, modified yellow birch veneer are shown in Fig. 2. The curves give an indication of the changes in the mechanical properties of the modified woods but are typical only of the actual densities and types of material tested.

A1. Modified wood involving the addition of some other material to the wood:

Impreg.—Wood that is impregnated with a water soluble A-stage or low-molecular resin compound for the primary purpose of improving the dimensional stability of the material.

Compreg.—Resin-impregnated wood that has been compressed under controlled conditions of heat and pressure for the primary purpose of modifying physical properties through densification and to improve dimensional stability.

A2. Modified wood involving modification of the wood itself by physical or chemical means:

Staypak.—Heat-stabilized, compressed wood that has been heated, during the pressing process under conditions such that the compression is not lost when the wood is subsequently swollen. Staypak has modified physical properties.

REDWOOD

Species

14. The material for test panels shall be redwood (*Sequoia sempervirens*).

Weight per Cubic Foot

15. The wood shall weigh 28 to 29 lb. per cu. ft. when it is in equilibrium with air at 60 to 65 per cent relative humidity and 69 to 71 F. (20.5 to 21.6 C.) (wood at approximately 12 per cent moisture content).

Character of Wood

16. The material shall be close grained, as nearly edge grain as possible, and in no section to vary more than 45 deg. from edge grain. The number of annual growth rings per inch along the radius of the log from which the wood was obtained shall be not less than 18. The wood shall be free of knots, oil streaks, and other defects such as wavy burl grain. The surfaces shall be smoothly planed and sanded.

Thickness of Panels

17. The minimum thicknesses (see Note, Section 5, in proportion to width (across the grain) shall be as follows:

Panel Width, in.	Minimum Thickness, in
3 and under	$\frac{3}{8}$
Over 3 to 6, incl.	$\frac{7}{16}$
Over 6	$\frac{3}{4}$

Standard Specifications for
CREOSOTE[1]

ASTM Designation: D 390 – 53

ADOPTED, 1935; REVISED, 1936, 1949, 1953.[2]

Reapproved in 1958 Without Change.

This Standard of the American Society for Testing Materials is issued under the fixed designation D 390; the final number indicates the year of original adoption as standard or, in the case of revision, the year of last revision.

Scope

1. These specifications cover creosote for use in the preservative treatment of timber, as defined in the Standard Definitions of Terms Relating to Timber Preservatives (ASTM Designation: D 324).[3] The creosote shall be a distillate derived entirely from tar produced by the carbonization of bituminous coal.

Properties

2. (*a*) Creosote shall conform to the following requirements:

Water, max, per cent	3.0
Benzene-insoluble matter[a] max, per cent	0.5
Specific gravity, 38/15.5 C, min	1.03
Distillation, based on water-free oil:	
Up to 210 C, max, per cent	5
Up to 235 C, per cent	5 to 25
Up to 270 C, min, per cent	20
Up to 355 C, per cent	60 to 85
Coke residue,[a] max, per cent	2.0

[a] Due to treating operations, samples of used creosote may show increases in matter insoluble in benzene, and in coke residue, and decreases in percentage of distillate up to 235 C. If it can be shown that the original creosote was of specified quality, and the used creosote conforms to the standard requirements with the following exceptions:

Benzene-insoluble matter, max, per cent	1.5
Coke residue, max, per cent	3.0
Distillate up to 235 C, min, per cent	2

It shall be considered as conforming.

(*b*) The specific gravity of the fraction between 235 and 315 C shall be not less than 1.025, and that of the fraction between 315 and 355 C not less than 1.085 at 38 C, compared with water at 15.5 C.

Sampling and Methods of Testing

3. The sampling and properties enumerated in these specifications shall be determined in accordance with the following methods of test of the American Society for Testing Materials:

(*a*) *Sampling.*—Standard Methods of Sampling and Testing Creosote (ASTM Designation: D 38).[3]

(*b*) *Water.*—Standard Method of Test for Water in Creosote (ASTM Designation: D 370)[3] or, as an alternate method, the Tentative Method of Test for Water in Petroleum Products and Other Bituminous Materials (ASTM Designation: D 95).[4]

(*c*) *Benzene-Insoluble Matter.*—Standard Methods of Test for Benzene-Insoluble Matter in Creosote (ASTM Designation: D 367).[3]

(*d*) *Specific Gravity.*—Standard Method of Test for Specific Gravity of Creosote (ASTM Designation: D 368).[3]

(*e*) *Distillation.*—Standard Method of

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[1] Under the standardization procedure of the Society, these specifications are under the jurisdiction of the ASTM Committee D-7 on Wood.

These specifications are identical in substance with the American Wood-Preservers' Association Standard Specifications for Creosote (P1-52).

[2] Prior to adoption as standard, these specifications were published as tentative from 1934 to 1935

[3] Appears in this publication, see Contents in Numeric Sequence of ASTM Designations at front of book.

[4] 1958 Book of ASTM Standards, Part 7.

Test for Distillation of Creosote (ASTM Designation: D 246).[3]

(*f*) *Specific Gravity of Fractions.*—Standard Method of Test for Specific Gravity, 38/15.5 C, of Creosote Fractions (ASTM Designation: D 369).[3]

(*g*) *Coke Residue.*—Standard Method of Test for Coke Residue of Creosote (ASTM Designation: D 168).[3]

(*h*) *Volume and Specific Gravity Correction.*—Standard Volume and Specific Gravity Correction Tables for Creosote and Coal Tar (ASTM Designation: D 347).[3]

Standard Specifications for

CREOSOTE - COAL TAR SOLUTION[1]

ASTM Designation: D 391 – 53

Adopted, 1950; Revised, 1953.[2]

Reapproved in 1958 Without Change.

This Standard of the American Society for Testing Materials is issued under the fixed designation D 391; the final number indicates the year of original adoption as standard or, in the case of revision, the year of last revision.

Scope

1. These specifications cover creosote-coal tar solution for use in the preservative treatment of wood.

Composition and Properties

2. Creosote - coal tar solution shall be a pure coal tar product derived entirely from tar produced by the carbonization of bituminous coal. It may be either a coal tar distillate or a solution of coal tar in coal tar distillate, and shall conform with the requirements for the respective grades specified in Table I.

Sampling and Methods of Testing

3. The material shall be sampled and the properties enumerated in these specifications shall be determined in accordance with the following methods of the American Society for Testing Materials:

TABLE I.—COMPOSITION AND PROPERTIES.

	Grade A		Grade B		Grade C	
	Min	Max	Min	Max	Min	Max
Coal tar distillate, per cent by volume...	80	...	70	...	60	...
Water, per cent by volume.....	...	3.0	...	3.0	...	3.0
Benzene-insoluble matter,[a] per cent by weight.	...	2.0	...	3.0	...	3.5
Coke residue,[a] per cent by weight.	...	5.0	...	7.0	...	9.0
Specific gravity at at 38/15.5 C. ..	1.06	1.11	1.07	1.12	1.08	1.13
Distillation—percentage of distillate by weight on water-free basis:						
Up to 210 C.....	...	5	...	5	...	5
Up to 235 C.....	5	25	5	25	5	25
Up to 315 C.....	36	...	34	...	32	...
Up to 355 C.....	60	...	56	...	52	...
Specific gravity of fractions:						
235 to 315 C at 38/15.5 C......	1.025	...	1.025	...	1.025	...
315 to 355 C at 38/15.5 C......	1.085	...	1.085	...	1.085	...

[a] Due to treating operations, samples of used creosote coal tar solutions may show increases in matter insoluble in benzene, and in coke residue, and decreases in percentage of distillate up to 235 C. If it can be shown that the original solution was of specified quality, and the used solution conforms to the standard requirements with the following exceptions:

	Grade A	Grade B	Grade C
Benzene-insoluble matter, max, per cent...............	3.0	4.0	4.5
Coke residue, max, per cent...	6.0	8.0	10.0
Distillate up to 235 C, min, per cent....................	2	2	2

it shall be considered as conforming.

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[1] Under the standardization procedure of the Society, these specifications are under the jurisdiction of the ASTM Committee D-7 on Wood.

These specifications are identical in substance with the specifications for grades A, B, and C of the American Wood-Preservers' Association Standard Specifications for Creosote-Coal Tar Solutions (P2-51), except for the distillation range of used solutions.

[2] Prior to their present adoption as standard, these specifications were published as tentative from 1934 to 1935. They were adopted in 1935 and published as standard from 1935 to 1949, being revised in 1936. They were reverted to tentative and revised in 1949, and were published as tentative from 1949 to 1950.

(*a*) *Sampling.*—Standard Methods of Sampling and Testing Creosote (ASTM Designation: D 38).[3]

(*b*) *Water.*—Standard Method of Test for Water in Creosote (ASTM Designation: D 370)[3] or, as an alternate method, the Tentative Method of Test for Water in Petroleum Products and Other Bituminous Materials (ASTM Designation: D 95).[3]

(*c*) *Benzene-Insoluble Matter.*—Standard Methods of Test for Benzene-Insoluble Matter in Creosote (ASTM Designation: D 367).[3]

(*d*) *Specific Gravity.*—Standard Method of Test for Specific Gravity of Creosote (ASTM Designation: D 368).[3]

(*e*) *Distillation.*—Standard Method of Test for Distillation of Creosote (ASTM Designation: D 246).[3]

(*f*) *Specific Gravity of Fractions.*—Standard Method of Test for Specific Gravity, 38/15.5 C, of Creosote Fractions (ASTM Designation: D 369).[3]

(*g*) *Coke Residue.*—Standard Method of Test for Coke Residue of Creosote (ASTM Designation: D 168).[4]

(*h*) *Volume and Specific Gravity Correction.*—Standard Volume and Specific Gravity Correction Tables for Creosote and Coal Tar (ASTM Designation: D 347).[3]

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[3] Appears in this publication, see Contents in Numeric Sequence of ASTM Designations at front of book.

[4] 1958 Book of ASTM Standards, Parts 4 and 7.

Standard Specifications for

ZINC CHLORIDE[1]

ASTM Designation: D 432 – 50

Adopted, 1950.[2]

Reapproved in 1953 Without Change.

This Standard of the American Society for Testing Materials is issued under the fixed designation D 432; the final number indicates the year of original adoption as standard or, in the case of revision, the year of last revision.

Scope

1. These specifications cover zinc chloride, either in the dry, fused or granulated, form or in commercial concentrated solutions, for use in the preservative treatment of wood.

Composition and Properties

2. (*a*) *Dry Form.*—Zinc chloride in the dry, fused or granulated, form shall conform to the following requirements:

Water-soluble zinc, calculated as $ZnCl_2$, min, per cent	94
Total zinc, calculated as $ZnCl_2$, min, per cent	96
Total chloride, calculated as $ZnCl_2$, min, per cent	96
Water-insoluble matter, max, per cent	1.6
Iron and aluminum, calculated as $Fe_2O_3 + Al_2O_3$ max, per cent	0.2

(*b*) *Concentrated Solution.*—The commercial concentrated solution shall be a 50 per cent solution of zinc chloride conforming to the following requirements:

Specific gravity at 100 F	1.547 to 1.567
Total zinc, calculated as $ZnCl_2$, min, per cent	50
Total chloride, calculated as $ZnCl_2$, min, per cent	50
Iron and aluminum, calculated as $Fe_2O_3 + Al_2O_3$, max, per cent	0.1
Alkalinity of a sample of the solution, diluted with 12 times its volume of freshly boiled distilled water	basic to methyl orange

Chemical Analysis

3. The material shall be analyzed in accordance with the Methods of Chemical Analysis of Zinc Chloride (ASTM Designation: D 199).[3]

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[1] Under the standardization procedure of the Society, these specifications are under the jurisdiction of the ASTM Committee D-7 on Wood.

These specifications are essentially the same as the specifications for zinc chloride in Section 1 of the American Wood Preservers' Association Standard Specifications for Salt Preservatives (P5-49).

[2] Prior to their present adoption as standard, these specifications were published as tentative from 1936 to 1939. They were adopted in 1939 and published as standard from 1939 to 1949. They were reverted to tentative and revised in 1949, and were published as tentative from 1949 to 1950.

[3] See p. 297.

Standard Specifications for

CHROMATED ZINC CHLORIDE[1]

ASTM Designation: D 1032 – 50

ADOPTED, 1950.[2]

Reapproved in 1958 Without Change.

This Standard of the American Society for Testing Materials is issued under the fixed designation D 1032; the final number indicates the year of original adoption as standard or, in the case of revision, the year of last revision.

Scope

1. These specifications cover chromated zinc chloride, either in the dry, granulated form or in commercial concentrated solutions, for use in the preservative treatment of wood.

Composition and Properties

2. (*a*) *Dry Form.*—Chromated zinc chloride in the dry, granulated form shall conform to the following requirements:

Total zinc, calculated as $ZnCl_2$, min., per cent	77.5
Hexavalent chromium, calculated as $Na_2Cr_2O_7 \cdot 2H_2O$,[a] min., per cent	17.5

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[a] This may include chromium trioxide (CrO_3) sufficient to produce in a 3 per cent solution of the chromated zinc chloride a pH not lower than 3.0 as determined by a glass electrode or by pH paper that has been standardized against a glass electrode.

(*b*) *Concentrated or Fresh Working Solutions.*—Chromated zinc chloride in commercial concentrated solutions or fresh working solutions shall contain zinc calculated as $ZnCl_2$ and chromium calculated as $Na_2Cr_2O_7 \cdot 2H_2O$ in the proportion specified in Paragraph (*a*).

NOTE.—Samples of chromated zinc chloride treating solution taken from working tanks or treating cylinder may show changes in composition as a result of treating operations. Such changes should not serve to cause rejection of the the preservative if they do not raise the ratio of $ZnCl_2$ to $Na_2Cr_2O_7 \cdot 2H_2O$ to more than 8 to 1 and if it can be shown that the original fresh preservative was of the specified composition.

Chemical Analysis

3. The material shall be analyzed in accordance with the Standard Methods of Chemical Analysis of Chromated Zinc Chloride (A.S.T.M. Designation: D 1033).[3]

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[1] Under the standardization procedure of the Society, these specifications are under the jurisdiction of the A.S.T.M. Committee D-7 on Wood.

These specifications are identical in substance with the specifications for chromated zinc chloride in Section 2 of the American Wood-Preservers' Association Standard Specifications for Salt Preservatives (P5-49).

[2] Prior to adoption as standard, these specifications were published as tentative from 1949 to 1950.

[3] See p. 301.

Standard Specifications for

COPPERIZED CHROMATED ZINC CHLORIDE[1]

ASTM Designation: D 1271 – 56

ADOPTED, 1956.[2]

This Standard of the American Society for Testing Materials is issued under the fixed designation D 1271; the final number indicates the year of original adoption as standard or, in the case of revision, the year of last revision.

Scope

1. These specifications cover copperized chromated zinc chloride, either in the dry, granulated form or in commercial concentrated solutions, for use in the preservative treatment of wood.

Composition and Properties

2. (*a*) *Dry Form.*—Copperized chromated zinc chloride in the dry, granulated form shall conform to the following requirements:

	Minimum	Nominal
Total zinc, calculated as $ZnCl_2$ per cent	68.6	73.0
Hexavalent chromium, calculated as $Na_2Cr_2O_7 \cdot 2H_2O$, per cent	18.8	20.0
Copper, calculated as $CuCl_2 \cdot 2H_2O$, per cent	6.6	7.0

(*b*) *Concentrated or Fresh Working Solutions.*—Copperized chromated zinc chloride in commercial concentrated solutions or fresh working solutions shall contain zinc calculated as $ZnCl_2$, chromium calculated as $Na_2Cr_2O_7 \cdot 2H_2O$, and copper calculated as $CuCl_2 \cdot 2H_2O$ in proportions not less than those specified under minimum requirements in Paragraph (*a*).

NOTE.—Samples of copperized chromated zinc chloride treating solution taken from working tanks or treating cylinders may show changes in composition as a result of treating operations. Such changes should not serve to cause rejection of the preservative if they do not raise the ratio of $ZnCl_2$ to $Na_2Cr_2O_7 \cdot 2H_2O$ to more than 8 to 1, or the ratio of $ZnCl_2$ to $CuCl_2 \cdot 2H_2O$ to more than 25 to 1, and if it can be shown that the original fresh preservative was of the specified composition.

Chemical Analysis

3. The material shall be analyzed in accordance with the Methods for Chemical Analysis of Copperized Chromated Zinc Chloride (ASTM Designation: D 1273).[3]

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[1] Under the standardization procedure of the Society, these specifications are under the jurisdiction of the ASTM Committee D-7 on Wood.

These specifications are identical in substance with the Specifications for Copperized Chromated Zinc Chloride in Section 2 of the American Wood-Preservers' Association Standard Specifications for Salt Preservatives (P5-51).

[2] Prior to adoption as standard, these specifications were published as tentative from 1953 to 1956.

[3] See p. 304.

Standard Specifications for
AMMONIACAL COPPER ARSENITE[1]

ASTM Designation: D 1325 – 56

ADOPTED, 1956.[2]

This Standard of the American Society for Testing Materials is issued under the fixed designation D 1325; the final number indicates the year of original adoption as standard or, in the case of revision, the year of last revision.

Scope

1. These specifications cover ammoniacal copper arsenite solution for use in the preservative treatment of wood.

Composition and Properties

2. (*a*) The ingredients of ammoniacal copper arsenite solution shall be present in the following proportions:

	Minimum	Nominal
Copper, calculated as $Cu(OH)_2$, per cent of toxic material	55.7	57.7
Arsenic, calculated as As_2O_3, per cent of toxic material	38.7	40.7
Acetic acid, calculated as CH_3COOH, per cent of toxic material	...	1.6

(*b*) The ingredients listed in Paragraph (*a*) shall be dissolved in an aqueous solution of ammonia of a strength such that the ammonia content of the solution will be between 1.5 and 2.0 times the copper content when copper is calculated as $Cu(OH)_2$.

Chemical Analysis

3. The material shall be analyzed in accordance with the Standard Methods for Chemical Analysis of Ammoniacal Copper Arsenite (ASTM Designation: D 1326).[3]

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[1] Under the standardization procedure of the Society, these specifications are under the jurisdiction of the ASTM Committee D-7 on Wood.

By publication of these specifications, the American Society for Testing Materials does not undertake to insure anyone utilizing the specifications against liability for infringement of Letters Patent nor assume any such liability, and such publication should not be construed as a recommendation of any patented or proprietary application that may be involved.

[2] Prior to adoption as standard, these specifications were published as tentative from 1954 to 1956.

[3] See p. 308.

Standard Specifications for

PENTACHLOROPHENOL[1]

ASTM Designation: D 1272 – 56

ADOPTED, 1956.[2]

This Standard of the American Society for Testing Materials is issued under the fixed designation D 1272; the final number indicates the year of original adoption as standard or, in the case of revision, the year of last revision.

Scope

1. These specifications cover dry pentachlorophenol for use in the preservative treatment of wood.

Composition and Properties

2. Dry pentachlorophenol shall conform to the following requirements:

Chlorinated phenols, min, per cent	95
Sodium hydroxide insoluble matter, max, per cent	1
Freezing point, min, deg Cent	174

Chemical Analysis

3. The material shall be analyzed in accordance with the Standard Methods for Chemical Analysis of Pentachlorophenol (ASTM Designation: D 1274).[3]

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[1] Under the standardization procedure of the Society, these specifications are under the jurisdiction of the ASTM Committee D-7 on Wood.

These specifications are identical in substance with the specifications for pentachlorophenol in Section 1 of the American Wood-Preservers' Association Standard Specifications for Oil-Borne Preservatives (P8-51).

[2] Prior to adoption as standard, these specifications were published as tentative from 1953 to 1956.

[3] See p. 312.

Standard Specifications for

TANALITH[1]

ASTM Designation: D 1034 – 50

ADOPTED, 1950.[2]

This Standard of the American Society for Testing Materials is issued under the fixed designation D 1034; the final number indicates the year of original adoption as standard or, in the case of revision, the year of last revision.

Reapproved in 1958 Without Change.

Scope

1. These specifications cover dry Tanalith for use in the preservative treatment of wood.

Composition and Properties

2. (*a*) Dry Tanalith shall conform to the following requirements:

	Minimum	Nominal
Fluoride, calculated as NaF, per cent	22	25
Arsenate, calculated as Na_2HAsO_4, per cent	22	25
Chromate, calculated as Na_2CrO_4, per cent	34	37.5
Dinitrophenol, per cent	5.0	12.5

(*b*) The minimum proportions may be as shown in Paragraph (*a*), but the dry Tanalith shall contain at least 95 per cent of these active materials.

(*c*) The pH of a treating solution prepared from the Tanalith shall be between 7.2 and 7.8.

Chemical Analysis

3. The material shall be analyzed in accordance with the Methods of Chemical Analysis of Tanalith (ASTM Designation: D 1035).[3]

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[1] Under the standardization procedure of the Society, these specifications are under the jurisdiction of the ASTM Committee D-7 on Wood.

By publication of these specifications, the American Society for Testing Materials does not undertake to insure anyone utilizing the specifications against liability for infringement of Letters Patent nor assume any such liability, and such publication should not be construed as a recommendation of any patented or proprietary application that may be involved.

These specifications are identical in substance with the specifications for Tanalith in Section 3 of the American Wood Preservers' Association Standard Specifications for Salt Preservatives (P5-49).

[2] Prior to adoption as standard, these specifications were published as tentative from 1949 to 1950.

[3] See p. 314.

AMERICAN ASSOCIATION STATE
HIGHWAY OFFICIALS STANDARD
A.A.S.H.O. NO.: T 60

Standard Methods of

SAMPLING AND TESTING CREOSOTE[1]

ASTM Designation: D 38 – 33

Adopted, 1917; Revised, 1918, 1924, 1927, 1930, 1933.[2]

Reapproved in 1958 Without Change.

This Standard of the American Society for Testing Materials is issued under the fixed designation D 38; the final number indicates the year of original adoption as standard or, in the case of revision, the year of last revision.

Note.—Editorial changes in Sections 3 and 6 were made in January, 1955.

Scope

1. (*a*) Creosote and creosote-coal tar solutions are homogeneous liquids, except for their moisture content. At atmospheric temperatures, however, part of the creosote is usually in crystalline form, and it is accordingly necessary before sampling that the creosote shall be heated to a temperature at which it is entirely liquid.

(*b*) When sampling creosote, the object is to obtain a sample that will be representative of the water content, and the methods of sampling described or referred to in Sections 2 to 7 are intended to accomplish that purpose.

Methods of Sampling

Continuous-Drip Sampling Method

Application

2. The continuous-drip method of sampling is applicable wherever the creosote is being loaded or discharged from tank ships or barges by means of pumping.

Procedure

3. Insert a $\frac{1}{2}$-in. sampling pipe in the line through which the oil is being pumped, on the discharge side of the pump and preferably in a rising section of the pipe line. This sampling pipe shall extend half way to the center of the main pipe, with the inner open end of the sampling pipe turned at an angle of 90 deg and facing the flow of the liquid. The sampling pipe shall be provided with a plug cock and shall discharge into a receiver of 50 to 100-gal capacity. Adjust the plug cock so that with a steady continuous flow of the oil the receiver will be filled in the time required to pump the entire shipment. The receiver shall be provided with a steam coil sufficient to keep the contents at a temperature not exceeding 120 F. Immediately upon completion of the pumping, very thoroughly mix the contents of the receiver by agitation, rolling, or shaking, and immediately take duplicate 1-qt samples by

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[1] Under the standardization procedure of the Society, these methods are under the jurisdiction of the ASTM Committee D-7 on Wood.

[2] Prior to adoption as standard, these methods were published as tentative from 1915 to 1917, being revised in 1916 and 1917.

means of a thief for purpose of tests. The amount of the drip sample collected shall be not less than 1 gal for each 1000 gal of oil, except in the case of large boat shipments, where a maximum of 100 gal is sufficient.

Routine Zone Method of Sampling Tank Cars

Application

4. The zone sampling method is applicable to the routine sampling of creosote in tank cars. With suitable modification of the apparatus, this alternative or simplified method may also be applied to the sampling of creosote in storage tanks.

Apparatus

5. The sampling apparatus shall consist of a wide-mouthed vessel, attached to a wooden rod and fitted with a lid that can be withdrawn by means of a cord. The apparatus and markings on the rod shall be made substantially in accordance with the form and dimensions shown in Fig. 1.

Procedure

6. (*a*) First lower the sampling apparatus until the point marked "Zone No. 1" on the rod is level with the top of the dome of the tank car. Then remove the cover of the sampling can, allow the vessel to fill at that point, and slowly withdraw it. Exercise extreme care in lifting the rod so as not to disturb the contents of the sampling vessel.

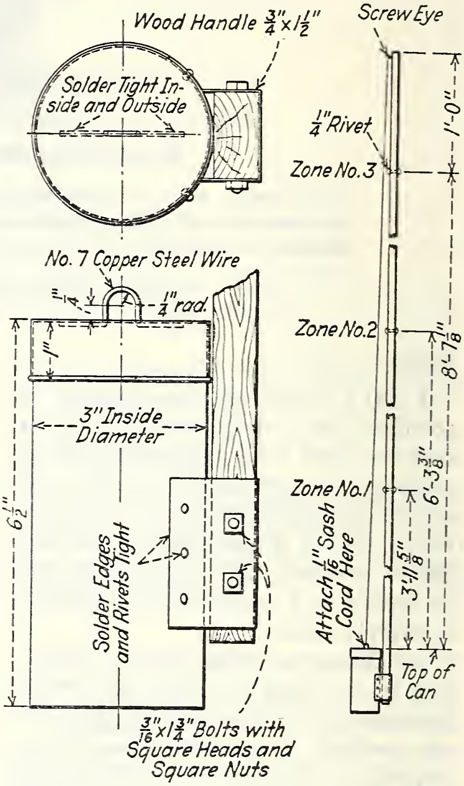
(*b*) Take two samples in a similar manner with the sampling apparatus lowered to the point marked "Zone No. 2," and take one sample likewise with the sampling apparatus lowered to the point marked "Zone No. 3."

(*c*) Combine the four samples and mix at once into a composite sample while the oil is thoroughly liquid. No sample shall be taken for analysis from oil that contains crystals.

Referee Method of Sampling Tank Cars

Procedure

7. In the case of dispute with reference to the water content of the shipment of creosote oil, sampling shall be carried out in accordance with the Standard Methods of Sampling Creosote Oil in Tank Cars of the American Wood Preservers' Association (Standard A 4 - 51)[3] or of the American Railway Engineering Association.[4]



Wood Handle $\frac{3}{4}$"x$1\frac{1}{2}$"
Screw Eye
Solder Tight Inside and Outside
$\frac{1}{4}$" Rivet
Zone No. 3
1'-0"
No. 7 Copper Steel Wire
$\frac{1}{4}$" rad.
1"
Zone No. 2
8'-$7\frac{7}{8}$"
3" Inside Diameter
6'-$3\frac{3}{8}$"
Zone No. 1
$6\frac{1}{2}$"
Solder Edges and Rivets Tight
Attach $\frac{1}{16}$" Sash Cord Here
3'-$11\frac{5}{8}$"
Top of Can
$\frac{3}{16}$"x$1\frac{3}{4}$" Bolts with Square Heads and Square Nuts

Fig. 1.—Routine Zone Sampling Apparatus.

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[3] *Manual of Recommended Practice*, Am. Wood-Preservers' Assn.

[4] *Manual*, Am. Railway Engineering Assn., Chapter 17, p. 173–5 (1953).

METHODS OF TESTING

Methods of Testing

8. Creosote shall be analyzed and tested in accordance with the following methods of test:

(*a*) *Water.*—Method of Test for Water in Creosote (ASTM Designation: D 370).[5]

(*b*) *Matter Insoluble in Benzene.*—Methods of Test for Benzene-Insoluble Matter in Creosote (ASTM Designation: D 367).[5]

(*c*) *Specific Gravity.*—Method of Test for Specific Gravity of Creosote (ASTM Designation: D 368).[5]

(*d*) *Distillation.*—Method of Test for Distillation of Creosote (ASTM Designation: D 246).[5]

(*e*) *Specific Gravity of Fractions.*—Method of Test for Specific Gravity, 38/15.5 C, of Creosote Fractions (ASTM Designation: D 369).[5]

(*f*) *Float Test of Residue.*—The residue remaining in the retort after the distillation test shall be preserved until it reaches a temperature between 100 and 125 C. The consistency of the residue shall then be determined in accordance with the Method of Float Test for Bituminous Materials (ASTM Designation: D 139).[6]

NOTE.—Care must be taken at the end of the distillation test to see that the vapor temperature as indicated on the thermometer does not rise above 355 C; an excess temperature of only 1 or 2 C at this point makes the float test invalid.

(*g*) *Coke Residue.*—Method of Test for Coke Residue of Creosote (ASTM Designation: D 168).[5]

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[5] Appears in this publication, see Contents in Numeric Sequence of ASTM Designations at front of book.

[6] 1958 Book of ASTM Standards, Part 4.

A.R.E.A. METHOD FOR COKE RESIDUE OF CREOSOTE
AMERICAN ASSOCIATION STATE HIGHWAY OFFICIALS STANDARD
A.A.S.H.O. NO.: T 61

Standard Method of Test for
COKE RESIDUE OF CREOSOTE[1]

ASTM Designation: D 168 - 30

Adopted, 1927; Revised, 1930.[2]

Reapproved in 1958 Without Change.

This Standard of the American Society for Testing Materials is issued under the fixed designation D 168; the final number indicates the year of original adoption as standard or, in the case of revision, the year of last revision.

Scope

1. This method of test covers the procedure for determining the coke residue (fixed carbon) in creosote or creosote - coal tar solution by coking the residue resulting from the distillation test and calculating the result based on the original oil.

Apparatus

2. (*a*) *Crucible.*—A platinum crucible, with tightly fitting cover of the inverted or capsule type having a depth of about 1 cm and provided with a hole 2 mm in diameter at its center. The crucible shall have a capacity of 25 to 30 ml and, with cover, shall weigh 25 to 30 g.

(*b*) *Furnace.*—A vertical electric tube furnace of the form shown in Fig. 1 or a Bunsen or Meker burner may be used.

Procedure

3. (*a*) The residue resulting from the distillation test, carried out in accordance with the Standard Method of Test for Distillation of Creosote (ASTM Designation: D 246),[3] shall be poured directly into the tared crucible or into a tin box wherein it may be heated on a water or steam bath, but not over a flame. A 1 ± 0.1-g portion of the residue shall be weighed into the covered crucible.

(*b*) If the vertical electric tube furnace is used, the temperature of the furnace shall be controlled by a thermocouple at 950 ± 20 C. The crucible shall be suspended in the electric furnace for exactly 7 min, after which it shall be removed, cooled, and weighed.

(*c*) If a Bunsen or Meker burner is used, it shall have a free flame 20 cm in height. The crucible shall set in a nichrome triangle with approximately two thirds of its height below the triangle and with the bottom of the crucible 6 to 8 cm above the top of the burner.

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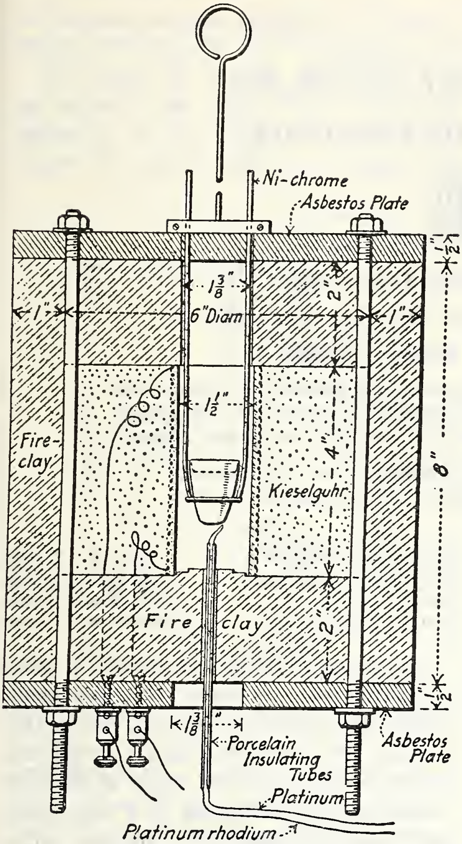
[1] Under the standardization procedure of the Society, this method is under the jurisdiction of the ASTM Committee D-7 on Wood.

This method is identical in substance with the Standard Method for the Determination of Coke Residue which is part of the American Wood Preservers' Association Standard Methods for Analysis of Creosote (A1-54).

[2] Prior to adoption as standard, this method was published as tentative from 1923 to 1927.

[3] See p. 254.



NOTE.—For 110-volt alternating current, 60 ft of Nichrome Wire, No. 17 B & S gage, will give there quired temperature. The temperature must be controlled by an external resistance (U. S. Bureau of Mines *Technical Paper No. 8*, p. 12 (1929)).

FIG. 1.—Electric Tube Furnace for Determining Coke Residue.

Assurance of the desired temperature of 950 ± 20 C may be indicated by the fusion of crystals of K_2CrO_4 in the crucible when exposed in the specified position for the test. The crucible and contents shall be exposed to the full flame of the burner for exactly 7 min.

Precautions

4. The test shall be conducted in a part of the laboratory free from draughts.

Calculations

5. The percentage of coke obtained from the residue in accordance with Section 3 shall be calculated to percentage of total oil as follows:

$$\text{Coke in oil} = \frac{A \times B}{100}$$

where:

A = percentage residue from oil distilled to 355 C, and

B = percentage of coke in the residue.

NOTE: *Example.*—With a retort distillation of 29 per cent of residue at 355 C, the residue containing 28 per cent of fixed carbon:

$$\text{Coke in oil} = \frac{29 \times 28}{100} = 8.1 \text{ per cent}$$

AMERICAN ASSOCIATION STATE
HIGHWAY OFFICIALS STANDARD
A.A.S.H.O. NO.: T 62

Standard Method of Test for
DISTILLATION OF CREOSOTE[1]

ASTM Designation: D 246 – 49

ADOPTED, 1928; REVISED, 1930, 1933, 1939, 1942, 1949.[2]

Reapproved in 1958 Without Change.

This Standard of the American Society for Testing Materials is issued under the fixed designation D 246; the final number indicates the year of original adoption as standard or, in the case of revision, the year of last revision.

NOTE.—This method was editorially revised in March, 1955. An editorial change in section 2(*e*) was made in March, 1958.

Scope

1. This method covers a distillation test suitable for all types and grades of creosote, tar, and mixtures of creosote with tars used for timber preservation.

Apparatus

2. (*a*) *Flask.*—A side-neck distillation flask as shown in Fig. 1, having the following dimensions:

Diameter of bulb, outside	86 ± 1.5 mm
Diameter of neck, inside	22 ± 1.0 mm
Diameter of tubulature, inside	10 ± 0.5 mm
Height of flask, outside	131 ± 1.5 mm
Vertical distance bottom of bulb, outside, to horizontal tangent at tubulature inside	93 ± 1.5 mm
Length of tubulature	220 ± 5.0 mm
Angle of tubulature	73 ± 2 deg
Thickness of tubulature wall	1.0 to 1.5 mm

(*b*) *Condenser Tube.*—A suitable form of tapered glass condenser tube, having the following dimensions:

Diameter of small end	12.5 ± 1.5 mm
Diameter of large end	28.5 ± 3.0 mm
Length	360.0 ± 4.0 mm
Length of tapered part	100.0 ± 5.0 mm

(*c*) *Source of Heat.*—A source of heat consisting of a bunsen or equivalent burner or an electric heater. The electric heater,[3] of the form and dimensions shown in Fig. 2, shall be made of asbestos cement and shall consist of a base plate and cover interlocked to prevent side-slipping, yet easily taken apart. The heating unit shall consist of an acid- and heat-resisting porcelain plate with coils of resistance wire of nickel-chromium alloy. It shall be a separate unit and readily renewable. The capacity of the heating unit shall be 600 w, and at full heat shall give a temperature of approximately 800 C at the coils. Temperature of the heater shall be controlled by a sliding-contact tube rheostat of the tube rheostat laboratory type, which shall be approximately 41 mm in diameter by 406 mm in length. The resistance and continuous-ampere capacity of the rheostat shall be suitable for the voltage used.

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[1] Under the standardization procedure of the Society, this method is under the jurisdiction of the ASTM Committee D-7 on Wood.

This method is identical in substance with the Standard Method of Distillation which is part of the American Wood Preservers' Association Standard Methods for Analysis of Creosote (A1-54).

[2] Prior to adoption as standard, this method was published as tentative from 1926 to 1928, being revised in 1927 and 1928.

[3] The Gilmer electric heater controlled by the sliding-contact tube rheostat has been found entirely satisfactory. For use with 110-v heaters, a 14-ohm, 6.5-amp rheostate should be used, and with 220-v heaters, a 25-ohm, 5-amp rheostat should be used.

(*d*) *Shield for Flame Distillation.*—A galvanized iron shield, lined with $\frac{1}{8}$-in. asbestos, of the form and dimensions shown in Fig. 3, used to protect the flask from air currents and to prevent radiation. If desired, the shield may be provided with a mica window to permit observation of the progress of distillation. The cover shall be made of asbestos-cement (Transite or equivalent) board and shall be in two parts conforming to the dimensions shown in Fig. 3.

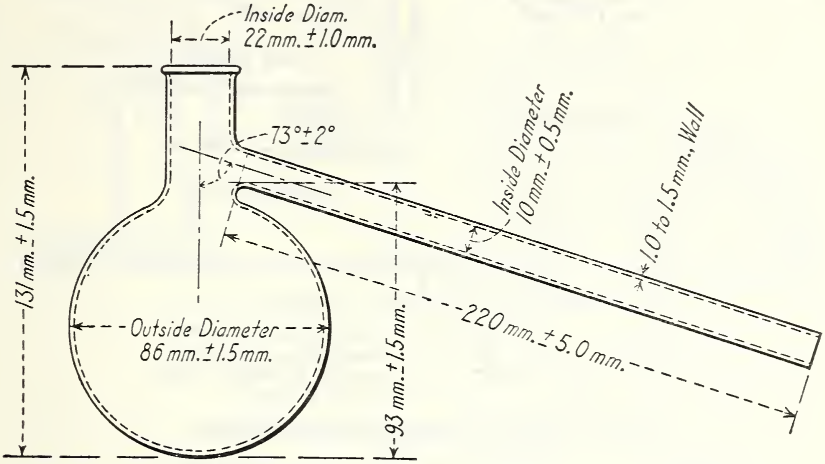
Inside Diam. 22 mm. ± 1.0 mm.
73° ± 2°
Inside Diameter 10 mm. ± 0.5 mm.
1.0 to 1.5 mm., Wall
131 mm. ± 1.5 mm.
Outside Diameter 86 mm. ± 1.5 mm.
93 mm. ± 1.5 mm.
220 mm. ± 5.0 mm.

Fig. 1.—Distillation Flask.

(*e*) *Shield for Electric-Heater Distillation.*—A galvanized-iron double-wall shield of the form and dimensions shown in Fig. 4, used to protect the flask from air currents and to prevent radiation. The space between the walls shall be 12 ± 2 mm and shall be filled with 85 per cent magnesia or powdered asbestos. If desired, the shield may be provided with a mica window to permit observation of the progress of distillation. The cover shall be made of Transite board and shall be in two parts conforming to the dimensions shown in Fig. 4.

(*f*) *Receivers.*—Tared Erlenmeyer flasks, having a capacity of 50 or 125 ml, for collecting the distillate.

(*g*) *Balance*, accurate to at least 0.05 g, for weighing the receivers and fractions.

(*h*) *Thermometer.*—An ASTM High Distillation Thermometer, total immersion, having a range of −2 to +400 C, and conforming to the requirements for thermometer 8C as prescribed in ASTM Specifications E 1.[4]

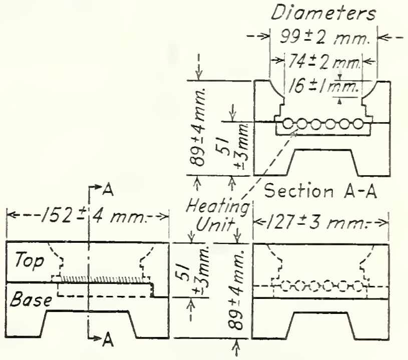

Fig. 2.—Electric Heater.

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[4] 1958 Book of ASTM Standards, Part 7.

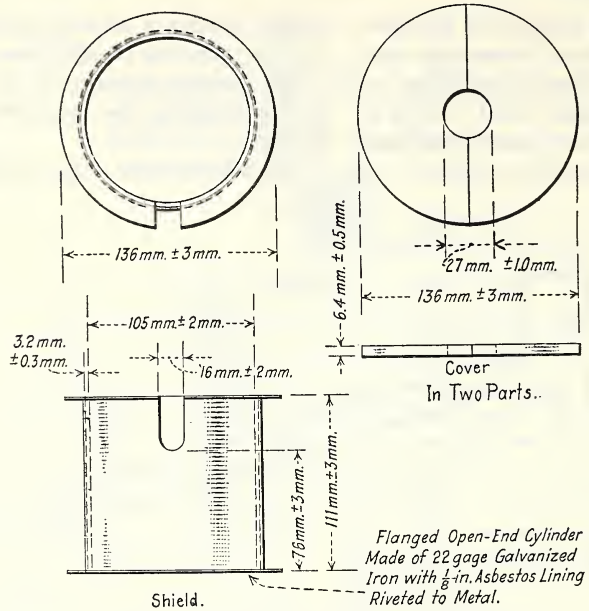

FIG. 3.—Shield and Cover for Flame Distillation.

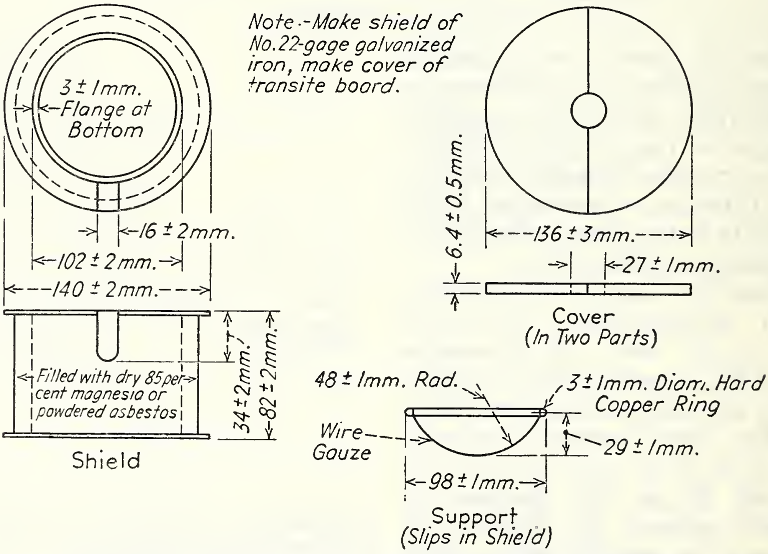
Note.-Make shield of No.22-gage galvanized iron, make cover of transite board.
3 ± 1 mm. Flange at Bottom
16 ± 2 mm.
102 ± 2 mm.
140 ± 2 mm.
Filled with dry 85 per cent magnesia or powdered asbestos
34 ± 2 mm.
82 ± 2 mm.
Shield
6.4 ± 0.5 mm.
136 ± 3 mm.
27 ± 1 mm.
Cover (In Two Parts)
48 ± 1 mm. Rad.
3 ± 1 mm. Diam. Hard Copper Ring
Wire Gauze
29 ± 1 mm.
98 ± 1 mm.
Support (Slips in Shield)

FIG. 4.—Shield, Cover, and Support for Electric-Heater Distillation.

Preparation of Sample

3. Thoroughly stir and agitate the sample as received, warming it if necessary to insure a complete mixture free of crystallized solids, before removing the portion for analysis.

Dehydration of Sample

4. If the presence of 3 per cent of

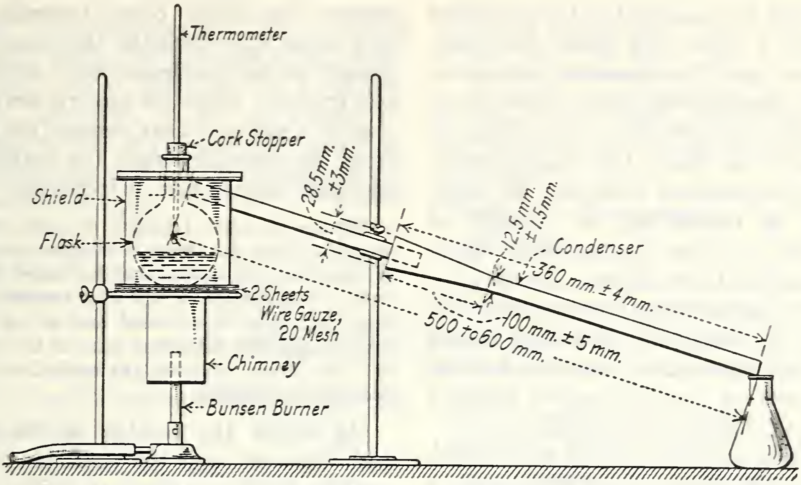

FIG. 5.—Apparatus Assembly for Flame Distillation.

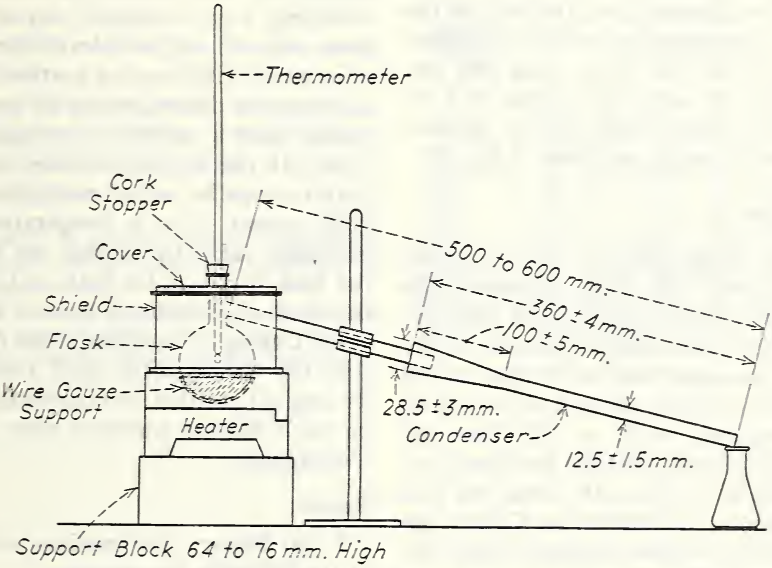

FIG. 6.—Apparatus Assembly for Electric-Heater Distillation.

water is suspected or known, the oil shall be dehydrated before distillation in accordance with the Standard Method of Test for Water in Creosote (ASTM Designation: D 370).[5]

Apparatus Assembly

5. (*a*) The flask shall be supported on a tripod or rings over two sheets of 20-mesh wire gauze, 150 mm square, as shown in Fig. 5, or mounted on the electric heater as shown in Fig. 6. The

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[5] See p. 276.

flask shall be connected to the condenser tube by a tight cork joint. The thermometer shall be inserted through a cork in the neck, with the bottom of the bulb 12 to 13 mm from the surface of the oil in the flask. The exact location of the thermometer bulb may be determined by calculating the number of divisions on the thermometer which are equal to 12 to 13 mm, lowering the tip of the bulb of the thermometer to the surface of the liquid, and then raising the thermometer the calculated number of degrees to give the correct distance from the surface of the liquid.

(*b*) The axis of the bulb of the flask through the center of the neck shall be vertical and the thermometer shall be aligned on this axis.

(*c*) The distance from the neck of the flask to the outlet end of the condenser tube shall be not more than 600 nor less than 500 mm. The burner shall be protected from drafts by a suitable shield or chimney, as shown in Fig. 5.

Procedure

6. (*a*) Weigh 100 ± 0.1 g of the sample into the flask, assemble the apparatus, and apply heat so that the first drop of the distillate falls from the end of the condenser in 10 min ± 100 sec (Note). Adjust the rate at the end of the condenser to 90 to 100 drops per min within 2 min after the first drop, and maintain it at 80 to 100 drops per min throughout the distillation. Collect the distillate in weighed receivers. Warm the condenser tube whenever necessary to prevent accumulation of solid distillates. Collect the fractions at the temperatures designated by the specifications, and change the receivers as the mercury passes the dividing temperature for each fraction. When the maximum specified temperature of the test is indicated by the thermometer, discontinue heating, remove the shield cover immediately, and drain any distillate that has condensed in the condenser tube into the last fraction. When the electric heater is used as a source of heat, remove the flask from the assembly when the maximum specified temperature is indicated.

NOTE.—In cases of routine or plant control analyses where the presence of water is known or suspected, the sample shall be heated slowly until a temperature of 150 C is reached. The heat shall then be increased and so regulated that the specified distillation rate will be reached in 5 min. From this point the method as specified shall be followed.

(*b*) Retain the residue in the flask with the cork and the thermometer in position until no vapors are visible; then weigh it. Tip the flask around so that the residue will flow around the sides, thus collecting any condensed vapors that have collected on the sides of the flask, after which withdraw the portion for the coke residue determination or pour the residue into a suitable receptacle, and cover. If the residue becomes so cool that it cannot be poured readily from the flask, reheat it to a temperature not exceeding 125 C by holding the bulb of the flask in a suitable bath and not by the direct application of flame or heat.

(*c*) During the progress of the distillation the thermometer shall remain in its original position. No correction shall be made for the emergent stem of the thermometer.

Report

7. (*a*) Report the fractions obtained at the following temperatures:

0 to 210 C
210 to 235 C[a]
235 to 270 C[a]
270 to 315 C
315 to 355 C
Residue

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[a] The fraction 235 to 270 C is not usually required in specifications for creosote, but it is recommended that this cut be made, since it gives useful information.

(*b*) If the fraction up to 210 C contains water, determine the amount of water (Note). Apply correction to water-free basis, according to the following formulas, to each of the fractions to express percentage based on the weight of the water-free sample.

Fraction to 210 C:

Percentage (water-free basis)

$$= (F - W) \times \frac{100}{100 - W}$$

Second and Subsequent Fraction Including Residue:

Percentage (water-free basis)

$$= F \times \frac{100}{100 - W}$$

where:

F = weight of the fraction, in grams, and

W = milliliters of water, expressed as grams, in the fraction distilling to 210 C (1 ml of water = 1 g (approx))

NOTE.—The amount of water contained in this fraction may be determined by either of the following methods:

(*1*) Transfer the fraction, after weighing, to a tube or cylinder graduated in $\frac{1}{10}$-ml divisions. Rinse the receiver several times with benzene, adding the rinsings to the tube or cylinder containing the fraction, or,

(*2*) The fraction up to 210 C may be collected in a tared 5-ml graduated cylinder having a flared top. After weighing, add benzene which will result in a clear separation of the water and oily distillate.

Distillation Temperatures at Various Altitudes

8. If the elevation at which the distillation is to be made exceeds 1000 ft, the temperatures at which the fractions are taken in accordance with Table I.

TABLE I.—TEMPERATURES AT WHICH CREOSOTE FRACTIONS SHALL BE CUT TO CORRECT DISTILLATION TEMPERATURES FOR DIFFERENT ALTITUDES.

(Corrections made to the nearest degree Centigrade)

Elevation Above Sea Level, ft	Fractionation Temperatures for Various Altitudes, deg Cent					
0.....	200	210	235	270	315	355
1000.....	198	208	233	268	313	353
1500.....	197	207	232	267	312	352
2000.....	196	206	231	266	311	351
2500.....	196	206	230	265	310	350
3000.....	195	205	230	264	309	349
3500.....	194	204	229	263	308	348
4000.....	193	203	228	263	307	347
4500.....	193	202	227	262	306	346
5000.....	192	202	226	261	305	344
5500.....	191	201	225	260	304	343
6000.....	190	200	225	260	303	343

APPROVED AS
AMERICAN STANDARD
BY THE AMERICAN STANDARDS ASSOCIATION
ASA NO.: Z11.7-1958
UDC 665.5: 620.1
FEDERATION OF PAINT AND VARNISH
PRODUCTION CLUBS STANDARD NO. Dt-5-58

Tentative Method of Test for

FLASH POINT BY PENSKY-MARTENS CLOSED TESTER[1]

ASTM Designation: D 93 - 58 T

Issued, 1958.[2]

This Tentative Method has been approved by the sponsoring committee and accepted by the Society in accordance with established procedures, for use pending adoption as standard. Suggestions for revisions should be addressed to the Society at 1916 Race St., Philadelphia 3, Pa.

Scope

1. This method of test describes a procedure for determining the flash point by Pensky-Martens closed tester of fuel oils as well as viscous materials and suspensions of solids, unless the use of another method is specified. This procedure is not applicable to drying oils, solvent-type liquid waxes, or cutback asphalts.

Note 1.—The flash point of cutback asphalts may be determined by Method D 1310, Test for Flash Point of Volatile Flammable Materials by Tag Open-Cup Apparatus.[3]

Note 2.—This method may be employed for the detection of contamination of lubricating oils by minor amounts of volatile material.

Outline of Method

2. The sample is heated at a slow, constant rate with continual stirring. A small flame is directed into the cup at regular intervals with simultaneous interruption of stirring. The flash point is the lowest temperature at which application of the test flame causes the vapor above the sample to ignite.

Apparatus

3. (*a*) *ASTM Pensky-Martens Tester* as described in Specifications E 134, for Pensky-Martens Closed Flash Tester.[3]

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[1] Under the standardization procedure of the Society, this method is under the jurisdiction of the ASTM Committee D-2 on Petroleum Products and Lubricants.

[2] Reverted to tentative and revised by action of the Society at the Annual Meeting, June, 1958.

Prior to its present publication as tentative, this method was published as tentative from 1921 to 1922, being revised in 1922. It was published as standard from 1922 to 1958, being revised in 1936, 1940, 1942, 1946, and 1952, and editorially revised in 1954.

In 1958, the method was completely revised and rewritten. Revisions included removal of cut-back asphalts from the scope, a new procedure for determining the flash point of suspensions of solids, and new precision criteria based on cooperative testing.

[3] 1958 Book of ASTM Standards, Part 8.

(*b*) *Thermometers.*—Two standard thermometers shall be used with the ASTM Pensky-Martens tester, as follows:

(*1*) For tests in which the indicated reading falls within the limits 20 to 220 F, inclusive, an ASTM Pensky-Martens Low Range or Tag Closed Tester Thermometer having a range of -5 to $+110$ C or 20 to 230 F and conforming to the requirements for thermometers 9C and 9F as prescribed in ASTM Specifications E 1[3] shall be used.

(*2*) For tests in which the indicated reading falls within the limits 220 to 700 F, an ASTM Pensky-Martens High Range Thermometer having a range of 90 to 370 C or 200 to 700 F and conforming to the requirements for thermometers 10C and 10F as prescribed in ASTM Specifications E 1[3] shall be used.

(*3*) The flash point as determined by means of thermometer 9F or 9C shall govern with respect to establishing if thermometer 10F or 10C is to be employed.

NOTE 3.—Whenever thermometers complying with ASTM requirements are not available, thermometers complying with the corresponding requirements of the Institute of Petroleum IP 15 F (or 15 C) PM—Low, or IP 16 F (or 16 C) PM—High, may be used. Calibration corrections are to be used in temperature ranges where the IP requirements for scale accuracy are less stringent than those of ASTM.

Preparation of Apparatus

4. Support the tester on a level, steady table. Unless tests are made in a draft-free room or compartment, it is good practice, but not required, to surround the tester on three sides with a shield, each section of which is about 18 in. (46 cm) wide and 24 in. (61 cm) high.

Preparation of Sample

5. (*a*) If the sample displays a haze or contains free water, bring it to a temperature at least 30 F (16 C) below its flash point and filter it through qualitative filter paper into a previously dried and cool container. For viscous samples it may be preferable to filter the sample through a loose plug of absorbent cotton.

(*b*) The sample, free of undissolved water, shall be brought to a temperature at least 30 F (16 C) below its expected flash point.

Procedure

6. (*a*) Thoroughly clean and dry all parts of the cup and its accessories before starting the test. Take particular care to remove any gasoline or naphtha which had been used to clean the apparatus. Fill the cup with the oil to be tested to the level indicated by the filling mark. Place the lid on the cup and set the latter in the stove. Take care to have the locking device properly engaged. Insert the thermometer. Light the test flame and adjust it to $\frac{5}{32}$ in. (4 mm) in diameter. Supply heat at such a rate that the temperature as read on the thermometer increases 9 to 11 F (5 to 6 C) per min. Turn the stirrer 90 to 120 rpm, stirring in a downward direction.

(*b*) If the sample is known to have a flash point of 220 F or below, apply the test flame when the temperature of the sample reaches 18 F (10 C) below the expected flash point, and thereafter at each temperature reading that is a multiple of 2 F (1 C). The test flame is applied by operating the mechanism on the cover which controls the shutter and test flame burner so that the flame is lowered into the vapor space of the cup in 0.5 sec, left in its lowered position for 1 sec, and quickly raised to its high position. Discontinue stirring while applying the test flame.

(*c*) If the sample is known to have a flash point above 220 F, apply the test flame in the manner just prescribed at each temperature that is a multiple of 5 F (2 C), beginning at a temperature of 30 F (16 C) below the expected flash point. In order to maintain the test flame, it may be necessary to lower it into the vapor space of the cup in 1 sec.

(*d*) Record as the flash point the temperature read on the thermometer at the time the test flame application causes a distinct flash in the interior of the cup. Sometimes the test flame during application is surrounded with a bluish halo as the flash point temperature is approached. Do not confuse the true flash with this halo.

Determination of Flash Point of Suspensions of Solids

Procedure

7. Bring the material to be tested and the tester to a temperature of 60 ± 10 F (15 ± 5 C) or 20 F (11 C) lower than the estimated flash point, whichever is lower. Completely fill the air space between the cup and the interior of the air bath with water at the temperature of the tester and sample. Turn the stirrer 250 ± 10 rpm, stirring in a downward direction. Raise the temperature throughout the duration of the test at a rate of not less than 2 nor more than 3 F (1 to 1.5 C) per min. With the exception of these requirements for rates of stirring and heating, proceed as prescribed in Section 6.

NOTE 4.—Solid carbon dioxide (CO_2) (Dry Ice) shall in no case be used to obtain the proper rate of temperature rise, since CO_2 has a blanketing effect which leads to a false flash point.

Barometric Pressure

8. Observe and record the barometric pressure. No correction shall be made except in case of dispute when the result shall be corrected on the following basis: for each inch (25 mm) below 29.92 in. (760 mm) barometric reading, add 1.6 F (0.9 C) to the flash point; for each inch (25 mm) above 29.92 in. (760 mm) barometric reading, subtract 1.6 F (0.9 C) from the flash point.

Precision

9. The following data should be used for judging the acceptability of results (95 per cent Probability):

(*a*) *Repeatability.*—Duplicate results by the same operator should be considered suspect if they differ by more than the following amounts:

Material	Flash Point Range	Repeatability
Suspensions of solids.........	95 to 110 F	4 F
All others.......	Below 220 F	4 F
	Above 220 F	20 F

(*b*) *Reproducibility.*—The results submitted by each of two laboratories should be considered suspect if they differ from each other by more than the following amounts:

Material	Flash Point Range	Reproducibility
Suspensions of solids.........	95 to 110 F	6 F
All others.......	Below 220 F	6 F
	Above 220 F	25 F

Standard Methods of Test for

BENZENE-INSOLUBLE MATTER IN CREOSOTE[1]

ASTM Designation: D 367 – 49

ADOPTED, 1933; REVISED, 1949.

Reapproved in 1958 Without Change.

This Standard of the American Society for Testing Materials is issued under the fixed designation D 367; the final number indicates the year of original adoption as standard or, in the case of revision, the year of last revision.

Scope

1. These methods are intended for the determination of benzene-insoluble matter in creosote and creosote-coal tar solutions. The asbestos mat method is the preferred method, while the porous thimble method may be used as an alternate. The asbestos mat method gives accurate results and requires 3 or 4 hr. less time than the porous thimble extraction method.

ASBESTOS MAT METHOD

Apparatus and Materials

2. The apparatus and materials shall consist of the following:

(*a*) *Filter Flask* with crucible holder and means for producing a vacuum.

(*b*) *Asbestos Fiber.*—A water suspension of medium-fiber acid-washed asbestos containing from 10 to 15 g. of asbestos per liter.

(*c*) *Filtering Medium* consisting of a Coors No. 3, or equivalent, Gooch filtering crucible approximately 35 mm. in diameter at the top, 22 mm. at the bottom, and 40 mm. in height, containing a mat of medium-fiber acid-washed asbestos weighing at least 0.5 g.

(*d*) *Balance* sensitive to 0.5 mg.

(*e*) *Benzene*, 2-deg. distillation range, conforming to the Standard Specifications for Industrial Grade Benzene (A.S.T.M. Designation: D 836).[2]

(*f*) *Acetone*, c.p.

Preparation of Filter Mat

3. Place the weighed Gooch crucible in the holder on the filter flask and pour in about 5 ml. of the well-shaken asbestos suspension. Let stand for about 1 min.; then apply gentle suction and suck the mat dry. Add in four increments the amount of suspension calculated to produce a mat weighing 0.5 g. When the required amount of asbestos has been added, wash the sides of the crucible free of particles and wash the mat at least

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[1] Under the standardization procedure of the Society, these methods are under the jurisdiction of the A.S.T.M. Committee D-7 on Wood.

These methods are identical in substance with the Standard Method for the Determination of the Amount of Material Insoluble in Benzol which is part of the American Wood Preservers' Association Standard Methods of Analysis of Creosote (M1-49).

[2] 1958 Book of ASTM Standards, Part 8.

three times with distilled water to ensure the removal of any loose material. Suck the crucible dry, remove it from the holder, and dry for at least 1 hr. at 105 ± 5 C. Cool in a desiccator and weigh

Procedure

4. (*a*) Use the original undehydrated sample. If necessary, heat the sample and stir until any crystalline material is in solution and the sample is homogeneous.

(*b*) Weigh the following size of sample, to the nearest 0.01 g., into a 100-ml. beaker or 125-ml. Erlenmeyer flask:

New grade I creosote	10 ± 1.0 g.
Used creosote and grade A solution	5 ± 0.5 g.
Grades C and B solutions	2.0 ± 0.1 g.

(*c*) Warm 50 ml. of benzene to a temperature of 50 to 60 C. and immediately add it to the sample, while stirring thoroughly. Continue stirring until the sample is dispersed and the bottom of the beaker is clean. Bring the beaker or flask containing the solution to boiling on a hot plate.

(*d*) Weigh a prepared crucible and mount in the suction apparatus. Fill the crucible halfway with boiling benzene and, with the suction turned on, slowly pour the mixture containing the sample into the crucible before the solution first introduced has been drawn entirely through the asbestos mat. Take care that the mat is never free from liquid, either during the addition of the solution containing the sample, or during the subsequent washing with benzene. *This is very important.* Wash the beaker or flask with hot benzene, using a policeman until clean, and adding the washings to the crucible. Wash the crucible and contents with hot benzene until the washings are colorless. Reduce the suction and wash the contents with acetone until the washings are colorless. Four additions of approximately 5 ml. each are usually sufficient.

(*e*) Remove the crucible from the holder and wipe the outside clean with a paper wet with benzene. Dry at 105 ± 5 C. for 20 min., cool in a desiccator, and weigh

(*f*) Determine the percentage of water in the original sample in accordance with the Standard Method of Test for Water in Creosote (A.S.T.M. Designation: D 370).[3]

Calculation

5. Calculate the benzene-insoluble matter as a percentage of the water-free preservative, as follows:

Benzene-insoluble matter, per cent =

$$\frac{100(A - B)}{C} \times \frac{100}{(100 - D)}$$

where:

A = weight of crucible after filtration, in grams,

B = weight of prepared crucible before filtration, in grams,

C = weight of sample used, in grams,

D = percentage of water in the sample.

POROUS THIMBLE METHOD

Apparatus and Materials

6. The apparatus and materials shall consist of the following:

(*a*) *Extractor* of the form shown in Fig. 1, in which a thimble containing the sample is subjected to direct washing by the hot solvent. The extraction flask is fitted with a metal cap condenser.

(*b*) *Filtering Medium* consisting of a flat-bottom, 30 by 80-mm., RA 98 alundum thimble. It shall be suspended within the extraction flask in a wire basket hung from the condenser.

(*c*) *Balance* sensitive to 0.5 mg.

(*d*) *Benzene*, 2-deg. distillation range, conforming to A.S.T.M. Specifications D 836.

Procedure

7. (*a*) Use the original undehydrated sample. If necessary, heat the sample and

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[3] See p. 276.

stir until any crystalline material is in solution and the sample is homogeneous.

(*b*) Weigh the following size of sample, to the nearest 0.01 g., into a 100-ml. beaker or 125-ml. Erlenmeyer flask:

New grade I creosote	10 ± 1.0 g.
Used creosote and grade A solution	5 ± 0.5 g.
Grades B and C solutions	2.0 ± 0.1 g.

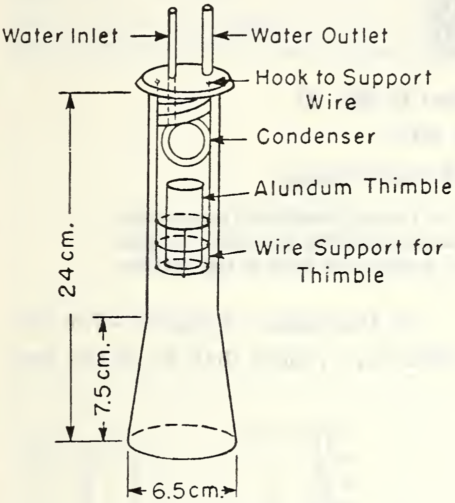

FIG. 1.—Extraction Flask.

(*c*) Warm 50 ml. of benzene to a temperature of 50 to 60 C. and immediately add it to the sample, while stirring thoroughly. Continue stirring until the sample is dispersed and the bottom of the beaker is clean.

(*d*) Prepare the thimbles for use by removing any insoluble material with a brush and igniting at a bright red heat in a muffle furnace or over a Meker burner until any combustible material has been burned off. Cool somewhat; then cool to room temperature in a desiccator and weigh.

(*e*) Wet a thoroughly clean, ignited and weighed thimble with approximately 10 ml. of benzene, pour out the excess, and immediately transfer the benzol solution of the sample into the wetted thimble; the solution shall not more than half fill the thimble at any time. Wash the beaker or flask with benzene, rub with a rubber policeman, and add the washings to the thimble.

(*f*) As soon as all the washings have been added to the thimble, place it in the extraction apparatus, which shall contain approximately 100 ml. of benzene. Heat sufficiently to maintain a continuous dropping of benzol from the condenser coil at a rate of not less than 60 drops per minute and a maximum rate that will leave 15 mm. of the thimble empty. Continue the extraction until solvent dropping from the thimble is colorless, but for a period of at least 3 hr.

(*g*) After extraction, remove the thimble from the flask and allow to drain free from benzene. Dry the thimble at 105 ± 5 C. for not less than 60 min., cool in a desiccator, and weigh.

Calculation

8. Calculate the benzene-insoluble matter as a percentage of the water-free preservative, as follows:

Benzene-insoluble matter, per cent =

$$\frac{100(A - B)}{C} \times \frac{100}{(100 - D)}$$

where:

A = weight of thimble after extraction, in grams,

B = weight of clean thimble before extraction, in grams,

C = weight of sample used, in grams, and

D = percentage of water in the sample.

A.R.E.A. METHOD OF TEST FOR SPECIFIC GRAVITY OF CREOSOTE

AMERICAN ASSOCIATION STATE HIGHWAY OFFICIALS STANDARD
A.A.S.H.O. NO.: T 82

Standard Method of Test for

SPECIFIC GRAVITY OF CREOSOTE[1]

ASTM Designation: D 368 - 33

ADOPTED, 1933.

Reapproved in 1958 Without Change.

This Standard of the American Society for Testing Materials is issued under the fixed designation D 368; the final number indicates the year of original adoption as standard or, in the case of revision, the year of last revision.

Scope

1. This method of test covers the procedure for determining the specific gravity of creosote by means of the hydrometer.

Apparatus

2. (*a*) *Hydrometer.*—The hydrometer shall be of glass of the conventional constant mass and variable displacement type as shown in Fig. 1. A set of two hydrometers with ranges in specific gravity of from 1.000 to 1.080 and from 1.070 to 1.150 will suffice. The scale shall be divided into 0.001 of a unit of specific gravity. The hydrometer shall be standardized at 15.5/15.5 C. and shall conform to the following requirements as to dimensions:

	Dimension, mm.	Permissible Variation, mm.
Length of stem	125	±6
Length of bulb	105	±5
Length of scale	80	±4
Diameter of stem	6	±0.5
Diameter of bulb	22	±1

(*b*) *Hydrometer Cylinder.*—The hydrometer cylinder shall be of the form shown in Fig. 2 and shall conform to the following requirements as to dimensions:

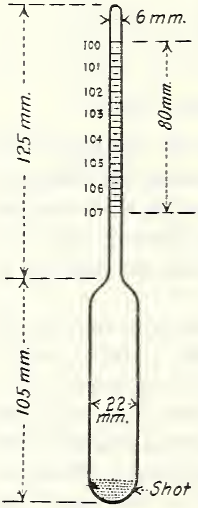

FIG. 1.—Hydrometer.

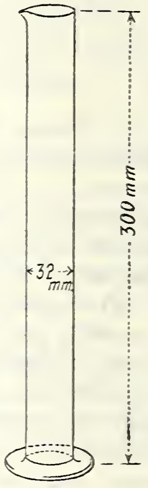

FIG. 2.—Hydrometer Cylinder.

Length	approximately 300 mm.
Diameter, inside	not less than 32 mm.

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[1] Under the standardization procedure of the Society, this method is under the jurisdiction of the A.S.T.M. Committee D-7 on Wood.

This method is identical in substance with the Standard Method for the Determination of the Specific Gravity of Oil Preservatives which is part of the American Wood Preservers' Association Standard Methods of Analysis of Creosote (M1-49).

Procedure

3. The sample of oil shall be brought to a temperature of 38 C. and the specific gravity shall be determined at that temperature unless the oil is not entirely liquid at 38 C. In case it is necessary to bring the oil to a temperature higher than 38 C. in order to render it completely fluid, the specific gravity shall be determined at the lowest temperature at which it is completely fluid. This observed specific gravity at the observed temperature shall be corrected to the specific gravity at 38 C. by the use of Table II of the Standard Volume and Specific Gravity Correction Tables for Creosote and Coal Tar (A.S.T.M. Designation: D 347) of the American Society for Testing Materials.[2]

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[2] See p. 273.

A.R.E.A. METHOD OF TEST FOR
SPECIFIC GRAVITY OF CREOSOTE FRACTIONS

AMERICAN ASSOCIATION STATE
HIGHWAY OFFICIALS STANDARD
A.A.S.H.O. NO.: T 74

Standard Method of Test for

SPECIFIC GRAVITY, 38/15.5 C., OF CREOSOTE FRACTIONS[1]

ASTM Designation: D 369 – 33

ADOPTED, 1933.[2]

Reapproved in 1958 Without Change.

This Standard of the American Society for Testing Materials is issued under the fixed designation D 369; the final number indicates the year of original adoption as standard or, in the case of revision, the year of last revision.

Scope

1. This method is a convenient and accurate means of determining the specific gravity of (*a*) creosote fractions (distilled at 235 to 315 C.) entirely liquid at 38 C., and (*b*) creosote fractions (distilled at 315 to 355 C.) containing solids at 38 C. It is also suitable for other distillation fractions of creosote or for creosote and creosote - coal tar solutions where only small amounts are available.

Apparatus

2. The apparatus shall consist of the following:

(*a*) *Pycnometers.*—Pycnometers of 10 and 25-ml. capacities with ground-glass stoppers having the usual capillary openings.

(*b*) *Water Bath.*—A water bath consisting of a vessel filled with sufficient water to permit of maintaining a temperature of 38 ± 0.1 C.

(*c*) *Thermometer.*—An A.S.T.M. Low Softening Point Thermometer graduated in Centigrade degrees, having a range of — 2 to + 80 C., and conforming to the requirements for thermometer 15C – 39 as prescribed in the Standard Specifications for A.S.T.M. Thermometers (A.S.T.M. Designation: E 1).[3]

(*d*) *Balance.*—An analytical balance accurate to 0.5 mg.

Calibration of Pycnometer

3. Before making a determination, the pycnometer with stopper shall first be calibrated as follows: Weigh the empty, clean, dry pycnometer with stopper upon the analytical balance. Fill the pycnometer with freshly boiled distilled water, place in the water bath, and bring the temperature to 38.0 ± 0.1 C. Insert stopper, wipe dry, and weigh.

Procedure for Fractions Entirely Liquid at 38 C.

4. The specific gravity of creosote fractions (distilled at 235 to 315 C.)

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[1] Under the standardization procedure of the Society, this method is under the jurisdiction of the A.S.T.M. Committee D-7 on Wood.

This method is identical in substance with the Standard Method for the Determination of the Specific Gravity of Distillation Fractions which is part of the American Wood Preservers' Association Standard Methods for Analysis of Creosote (M1–49).

[2] Prior to adoption as standard, this method was published as tentative from 1930 to 1933, being revised in 1933.

[3] 1958 Book of ASTM Standards, Part 7.

entirely liquid at 38 C. shall be determined as follows:

Heat the creosote fraction until completely liquid and continue heating to a temperature not exceeding 38 C.; then pour it into the empty, dry pycnometer until full, avoiding the formation of air bubbles. Insert the stopper in the pycnometer, taking precautions to avoid the inclusion of air bubbles. Place the filled pycnometer in the water bath maintained at a temperature of 38 ± 0.1 C. until the pycnometer and its contents are at a constant volume at 38 C. After immersion in the bath for at least 30 min., remove the pycnometer, wipe clean and dry; then weigh.

Procedure for Fractions Containing Solids at 38 C.

5. The specific gravity of creosote fractions (distilled at 315 to 355 C.) containing solids at 38 C. shall be determined as follows:

Heat the creosote fraction until completely liquid, and pour it into the empty, dry pycnometer until about one-half full, avoiding the inclusion of air bubbles. Cool to room temperature and weigh. Cover the solid or partially solid fraction with freshly boiled distilled water until the pycnometer is about three-quarters full; place in a water bath at 90 C. and allow to remain without agitation until the fraction is liquid and all air is removed. Cool the pycnometer and its contents to a temperature somewhat below 38 C.; fill the pycnometer with freshly boiled distilled water, avoiding the formation of air bubbles; and insert the stopper in the pycnometer, taking precautions to avoid the inclusion of air bubbles.

Place the filled pycnometer in the water bath maintained at a temperature of 38 ± 0.1 C. until the pycnometer and its contents are at a constant volume at 38 C. After immersion in the bath for at least 30 min., remove the pycnometer, wipe clean and dry; then weigh.

Calculations

6. The expression "38/15.5 C." means specific gravity of the fraction at 38 C. compared with water at 15.5 C. This cannot be determined directly. The specific gravity is first determined at 38 C. compared with water at 38 C. and this determination represents the relation of the weight of a volume of oil at 38 C. to the weight of an equal volume of water at the same temperature. The relation to an equal volume of water at 15.5 C. is obtained by multiplying the former figure by 0.99393—the density of water at 38 C. compared to water at 15.5 C., $\frac{(0.99299)}{(0.99905)}$. It is incorrect to calculate the specific gravity at 38/15.5 C. by dividing the weight of the oil determined at 38 C. by the weight of water taken at 15.5 C.

NOTE: *Examples.*—The following examples are given to illustrate the correct methods of calculation:

Fractions Entirely Liquid at 38 C.—The weight of the pycnometer is 19.1624 g.; the weight of the pycnometer filled with water is 43.8837 g.; the weight of the pycnometer filled with oil is 44.876 g.:

$$\text{Sp. gr. at 38/38 C.} = \frac{44.8676 - 19.1624}{43.8837 - 19.1624} = 1.0398$$

$$\text{Sp. gr. at 38/15.5 C.} = 1.0398 \times 0\ 99393 = 1.0335$$

Fractions Containing Solids at 38 C.—The weight of the pycnometer is 12.6370 g.; the weight of the pycnometer filled with water is 22.5708 g.; the weight of the pycnometer partially filled with oil is 17.4962 g.; the weight of the partially filled pycnometer completely filled with water is 23.0453 g.:

$$\text{Sp. gr. at 38/38 C.} = \frac{17.4962 - 12.6370}{(22.5708 - 12.6370) - (23.0453 - 17.4962)} = 1.1082$$

$$\text{Sp. gr. at 38/15.5 C.} = 1.1082 \times 0.99393 = 1.1015$$

Standard Method of Test for
TAR ACIDS IN CREOSOTE AND CREOSOTE-COAL TAR SOLUTIONS[1]

ASTM Designation: D 453 - 41

ADOPTED, 1941.[2]

Reapproved in 1958 Without Change.

This Standard of the American Society for Testing Materials is issued under the fixed designation D 453; the final number indicates the year of original adoption as standard or, in the case of revision, the year of last revision.

Scope

1. This method of test covers the procedure for determining the amount of tar acids in fractions distilled from creosote and creosote-coal tar solutions.

Apparatus

2. (*a*) *Type I Separatory Funnel.*—The type I glass separatory funnel shall conform to the requirements shown in Fig. 1. It shall have a total capacity of approximately 200 ml with the lower 20 ml graduated accurately in 0.1 ml. The graduation marks shall be numbered for each milliliter.

(*b*) *Type II Separatory Funnel.*—The type II glass separatory funnel shall have a total capacity of approximately 260 ml and shall conform to the requirements shown in Fig. 2. The capacity of the lower bulb from the stopcock to the first graduation mark shall be 65 ml, and above this mark the stem shall be graduated accurately for 100 ml in 0.2 ml. The graduation marks shall be numbered for each two milliliters.

Procedure

3. (*a*) In making the determination, distill 100 g of the sample in accordance with the Method of Test for Distillation of Creosote (ASTM Designation: D 246).[3] Transfer the fraction (Note) to be tested to a regular 250-ml glass-stoppered separatory funnel, and add 50 ml of cp benzol and 50 ml of an 18.3 per cent solution of NaOH (sp gr 1.20 at 20/4 C). Shake the mixture vigorously for 3 min and allow to settle. Draw off the well-settled lower portion of the liquid into a 250-ml beaker. Add an additional 30 ml of the NaOH solution (18.3 per cent) to the separatory funnel

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[1] Under the standardization procedure of the Society, this method is under the jurisdiction of the ASTM Committee D-7 on Wood.

This method is identical in substance with the Method for the Determination of Tar Acids which is part of the American Wood Preservers' Association Standard Methods for Analysis of Creosote (M1-49).

[2] Prior to adoption as standard, this method was published as tentative from 1937 to 1941, being revised in 1938 and 1939.

[3] See p. 254.

and gently shake the contents for 2 min. After settling, draw off the lower portion of the liquid and add it to the beaker containing the first portion. Add sufficient H_2SO_4 (1:3) to the mixture in the beaker to turn blue litmus paper definitely red. Cool the solution during the addition of the acid.

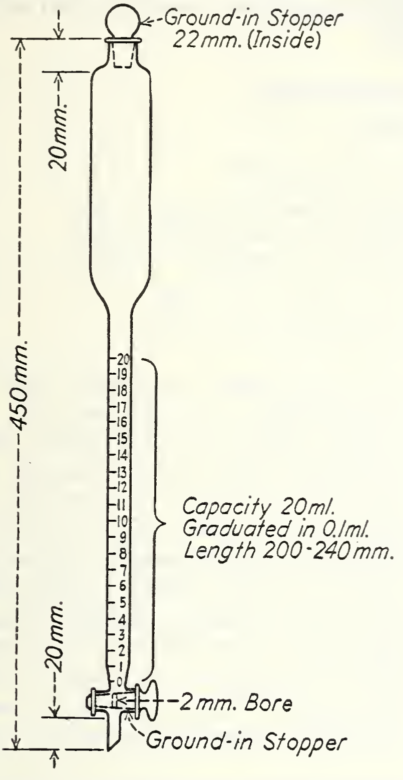

Fig. 1.—Type I Glass Separatory Funnel, 200-ml Capacity.

(*b*) If the tar acids liberated are estimated to be under 10 ml, use a type I separatory funnel (Fig. 1) and measure into it 10 ml of high-flash naphtha or cp benzol at 25 C. Then pour the liberated tar acids and sulfate solution through this layer of naphtha or benzol several times, drawing the material off at the bottom of the funnel into the original beaker and pouring it back into the top of the funnel. This washes out the beaker and allows all the tar acids to be absorbed. Allow the funnel to stand at 25 C, until the layers separate clearly, when the sulfate solution shall be drawn off and the increase in the volume of the naphtha or benzol taken as the dry tar acids present.

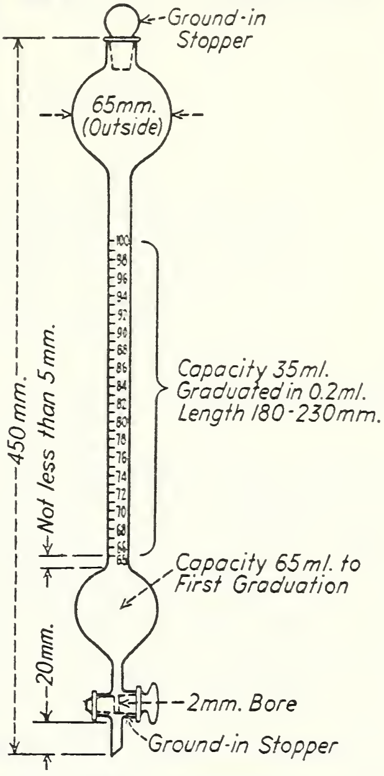

Fig. 2.—Type II Glass Separatory Funnel, 206-ml Capacity.

(*c*) If the tar acids liberated are estimated to be more than 10 ml follow the procedure described in Paragraph (*b*) except that 65 ml of high-flash naphtha or cp benzol at 25 C shall be measured into the type II separatory funnel (Fig. 2).

Note.—If the total content of tar acids in a sample is desired, the entire distillate below 355 C should be tested. In this case the results shall be reported as percentage by volume, that is, as the number of milliliters of tar acids per 100 ml of the original dry sample, both volumes measured at the same temperature.

Calculation

4. Report the result as a percentage of the fraction tested, calculated as follows:

$$\text{Tar acids, per cent} = \frac{G \times V}{W} \times 100$$

where:

G = specific gravity of the tar acids at 25 C/15.5 C,[a]
V = volume of tar acids in milliliters, and
W = weight of fraction in grams.

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[a] For practical purposes the specific gravity of the tar acids may be assumed to be 1.040.

CONFORMS TO
A.R.E.A. VOLUME AND SPECIFIC GRAVITY
CORRECTION TABLES

STANDARD VOLUME AND SPECIFIC GRAVITY CORRECTION TABLES FOR CREOSOTE AND COAL TAR[1]

ASTM Designation: D 347 – 33

Adopted, 1933.[2]

Reapproved in 1958 Without Change.

This Standard of the American Society for Testing Materials is issued under the fixed designation D 347; the final number indicates the year of original adoption as standard or, in the case of revision, the year of last revision.

Note.—The volumes for temperatures of 84 to 80 F in Table I were editorially corrected in February, 1954.

These tables have been prepared by the National Bureau of Standards to meet a demand from the wood preserving industry for convenient tables for reducing creosote volumes to the basis of 100 F. (38 C.) and for reducing specific gravity observations to the same temperature. Tables I and II give in parallel columns correction factors for creosote, and for mixtures of creosote and coal tar (up to 50 per cent tar) designated as solution, and for coal tar. They are based on density determinations made on a selected range of domestic and foreign creosote and domestic coke-oven tars.

Table I shows the volume occupied at 100 F. (38 C.) by a quantity of oil occupying a unit volume at the indicated temperature; for example, 1 gal. of creosote measured at 120 F. (49 C.) will have a volume of 0.9921 gal. at 100 F. (38 C.); thus, if the volume of creosote at 120 F. (49 C.) equals 10,000 gal., then the volume at 100 F. (38 C.) equals 10,000 times 0.9921 or 9,921 gal.

Table II gives corrections for observed specific gravity which are simply made by adding them to the observed values for temperatures above 100 F. (38 C.) and subtracting them for temperatures below 100 F. (38 C.).

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[1] Under the standardization procedure of the Society, these tables are under the jurisdiction of the A.S.T.M. Committee D-7 on Wood.

These tables have been adopted as standard by the American Wood Preservers' Association and by the American Railway Engineering Association; they are the outcome of a Joint Conference Committee representing these associations and the American Society for Testing Materials.

[2] Prior to adoption as standard, these tables were published as tentative from 1932 to 1933.

TABLE I.—VOLUME CORRECTION TABLE FOR CREOSOTE, CREOSOTE-COAL TAR SOLUTION (UP TO 50 PER CENT TAR), AND COAL TAR (COKE-OVEN TARS).

The observed volume is to be multiplied by the factor corresponding to the observed temperature.

Observed Temperature, deg. Fahr.	Volume at 100 F. Occupied by Unit Volume at Indicated Temperature			Observed Temperature, deg. Fahr.	Volume at 100 F. Occupied by Unit Volume at Indicated Temperature			Observed Temperature, deg. Fahr.	Volume at 100 F. Occupied by Unit Volume at Indicated Temperature		
	Creosote	Solution	Coal Tar		Creosote	Solution	Coal Tar		Creosote	Solution	Coal Tar
220	0.9526	0.9542	0.9594	180	0.9684	0.9696	0.9732	140	0.9842	0.9850	0.9867
219	0.9530	0.9546	0.9597	179	0.9687	0.9700	0.9735	139	0.9846	0.9853	0.9870
218	0.9534	0.9550	0.9600	178	0.9691	0.9704	0.9739	138	0.9850	0.9857	0.9874
217	0.9538	0.9554	0.9604	177	0.9695	0.9708	0.9742	137	0.9853	0.9861	0.9877
216	0.9542	0.9557	0.9607	176	0.9699	0.9712	0.9745	136	0.9857	0.9865	0.9880
215	0.9546	0.9561	0.9611	175	0.9703	0.9715	0.9749	135	0.9861	0.9868	0.9884
214	0.9550	0.9565	0.9614	174	0.9707	0.9719	0.9752	134	0.9865	0.9872	0.9887
213	0.9554	0.9569	0.9618	173	0.9711	0.9723	0.9756	133	0.9869	0.9876	0.9890
212	0.9558	0.9573	0.9621	172	0.9715	0.9727	0.9759	132	0.9873	0.9880	0.9894
211	0.9561	0.9577	0.9625	171	0.9719	0.9731	0.9762	131	0.9877	0.9884	0.9897
210	0.9565	0.9581	0.9628	170	0.9723	0.9735	0.9766	130	0.9881	0.9887	0.9900
209	0.9569	0.9584	0.9632	169	0.9727	0.9738	0.9769	129	0.9885	0.9891	0.9904
208	0.9573	0.9588	0.9635	168	0.9731	0.9742	0.9772	128	0.9889	0.9895	0.9907
207	0.9577	0.9592	0.9639	167	0.9735	0.9746	0.9776	127	0.9893	0.9899	0.9910
206	0.9581	0.9596	0.9642	166	0.9739	0.9750	0.9779	126	0.9897	0.9902	0.9914
205	0.9585	0.9600	0.9646	165	0.9743	0.9754	0.9783	125	0.9901	0.9906	0.9917
204	0.9589	0.9604	0.9649	164	0.9747	0.9758	0.9786	124	0.9905	0.9910	0.9920
203	0.9593	0.9608	0.9652	163	0.9751	0.9762	0.9789	123	0.9909	0.9914	0.9924
202	0.9597	0.9611	0.9656	162	0.9754	0.9765	0.9793	122	0.9913	0.9917	0.9927
201	0.9601	0.9615	0.9659	161	0.9758	0.9769	0.9796	121	0.9917	0.9921	0.9930
200	0.9605	0.9619	0.9663	160	0.9762	0.9773	0.9800	120	0.9921	0.9925	0.9934
199	0.9609	0.9623	0.9666	159	0.9766	0.9777	0.9803	119	0.9925	0.9929	0.9937
198	0.9612	0.9627	0.9670	158	0.9770	0.9781	0.9806	118	0.9929	0.9932	0.9940
197	0.9616	0.9631	0.9673	157	0.9774	0.9785	0.9810	117	0.9932	0.9936	0.9944
196	0.9620	0.9634	0.9677	156	0.9778	0.9788	0.9813	116	0.9936	0.9940	0.9947
195	0.9624	0.9638	0.9680	155	0.9782	0.9792	0.9816	115	0.9940	0.9944	0.9950
194	0.9628	0.9642	0.9684	154	0.9786	0.9796	0.9820	114	0.9944	0.9948	0.9954
193	0.9632	0.9646	0.9687	153	0.9790	0.9800	0.9823	113	0.9948	0.9951	0.9957
192	0.9636	0.9650	0.9690	152	0.9794	0.9804	0.9827	112	0.9952	0.9955	0.9960
191	0.9640	0.9654	0.9694	151	0.9798	0.9808	0.9830	111	0.9956	0.9959	0.9964
190	0.9644	0.9658	0.9697	150	0.9802	0.9811	0.9833	110	0.9960	0.9962	0.9967
189	0.9648	0.9662	0.9701	149	0.9806	0.9815	0.9837	109	0.9964	0.9966	0.9970
188	0.9652	0.9665	0.9704	148	0.9810	0.9819	0.9840	108	0.9968	0.9970	0.9974
187	0.9656	0.9669	0.9708	147	0.9814	0.9823	0.9844	107	0.9972	0.9974	0.9977
186	0.9660	0.9673	0.9711	146	0.9818	0.9827	0.9847	106	0.9976	0.9978	0.9980
185	0.9664	0.9677	0.9714	145	0.9822	0.9830	0.9850	105	0.9980	0.9981	0.9983
184	0.9668	0.9681	0.9718	144	0.9826	0.9834	0.9854	104	0.9984	0.9985	0.9987
183	0.9672	0.9685	0.9721	143	0.9830	0.9838	0.9857	103	0.9988	0.9989	0.9990
182	0.9676	0.9688	0.9725	142	0.9834	0.9842	0.9860	102	0.9992	0.9992	0.9993
181	0.9680	0.9692	0.9728	141	0.9838	0.9846	0.9864	101	0.9996	0.9996	0.9997
								100	1.0000	1.0000	1.0000

The portion of the table below should not be used unless the oil is entirely free from crystals.[a]

99	1.0004	1.0004	1.0003	84	1.0063	1.0062	1.0053	69	1.0122	1.0116	1.0103
98	1.0008	1.0008	1.0007	83	1.0067	1.0066	1.0056	68	1.0126	1.0120	1.0106
97	1.0012	1.0011	1.0010	82	1.0071	1.0070	1.0060	67	1.0130	1.0124	1.0109
96	1.0016	1.0015	1.0013	81	1.0075	1.0074	1.0063	66	1.0134	1.0127	1.0112
95	1.0020	1.0019	1.0017	80	1.0079	1.0078	1.0066	65	1.0138	1.0131	1.0116
94	1.0024	1.0022	1.0020	79	1.0083	1.0079	1.0070	64	1.0142	1.0135	1.0119
93	1.0028	1.0026	1.0023	78	1.0087	1.0082	1.0073	63	1.0146	1.0138	1.0122
92	1.0032	1.0030	1.0026	77	1.0091	1.0086	1.0076	62	1.0150	1.0142	1.0126
91	1.0036	1.0034	1.0030	76	1.0095	1.0090	1.0080	61	1.0154	1.0146	1.0129
90	1.0040	1.0038	1.0033	75	1.0099	1.0094	1.0083	60	1.0158	1.0150	1.0132
89	1.0043	1.0041	1.0036	74	1.0103	1.0097	1.0086				
88	1.0047	1.0045	1.0040	73	1.0107	1.0101	1.0089				
87	1.0051	1.0049	1.0043	72	1.0111	1.0105	1.0093				
86	1.0055	1.0052	1.0046	71	1.0115	1.0109	1.0096				
85	1.0059	1.0056	1.0050	70	1.0118	1.0112	1.0099				

[a] The volumes for temperatures of 84 to 80 F. were editorially corrected in February, 1954.

TABLE II.—SPECIFIC GRAVITY CORRECTION TABLE FOR CREOSOTE, CREOSOTE-COAL TAR SOLUTION (UP TO 50 PER CENT TAR), AND COAL TAR (COKE-OVEN TARS).

Observed Temperature, deg. Fahr.	Add to Observed Specific Gravity			Observed Temperature, deg. Fahr.	Add to Observed Specific Gravity			Observed Temperature, deg. Fahr.	Add to Observed Specific Gravity		
	Creosote	Solution	Coal Tar		Creosote	Solution	Coal Tar		Creosote	Solution	Coal Tar
220	0.0491	0.0481	0.0451	180	0.0326	0.0319	0.0299	140	0.0161	0.0158	0.0148
219	0.0487	0.0477	0.0447	179	0.0322	0.0315	0.0295	139	0.0157	0.0154	0.0144
218	0.0483	0.0473	0.0443	178	0.0318	0.0311	0.0291	138	0.0153	0.0150	0.0141
217	0.0479	0.0469	0.0439	177	0.0314	0.0307	0.0288	137	0.0149	0.0146	0.0137
216	0.0475	0.0465	0.0436	176	0.0309	0.0303	0.0284	136	0.0145	0.0142	0.0133
215	0.0471	0.0460	0.0432	175	0.0305	0.0298	0.0280	135	0.0141	0.0138	0.0130
214	0.0467	0.0456	0.0428	174	0.0301	0.0294	0.0276	134	0.0137	0.0134	0.0126
213	0.0462	0.0452	0.0424	173	0.0297	0.0290	0.0272	133	0.0133	0.0130	0.0122
212	0.0458	0.0448	0.0420	172	0.0293	0.0286	0.0269	132	0.0129	0.0126	0.0118
211	0.0454	0.0444	0.0417	171	0.0289	0.0282	0.0265	131	0.0125	0.0122	0.0115
210	0.0450	0.0440	0.0413	170	0.0284	0.0278	0.0261	130	0.0121	0.0118	0.0111
209	0.0446	0.0436	0.0409	169	0.0280	0.0274	0.0257	129	0.0117	0.0114	0.0107
208	0.0442	0.0432	0.0405	168	0.0276	0.0270	0.0254	128	0.0113	0.0110	0.0104
207	0.0438	0.0428	0.0401	167	0.0272	0.0266	0.0250	127	0.0109	0.0106	0.0100
206	0.0434	0.0424	0.0398	166	0.0268	0.0262	0.0246	126	0.0105	0.0102	0.0096
205	0.0430	0.0420	0.0394	165	0.0264	0.0258	0.0242	125	0.0101	0.0098	0.0092
204	0.0426	0.0416	0.0390	164	0.0260	0.0254	0.0238	124	0.0097	0.0094	0.0089
203	0.0422	0.0412	0.0386	163	0.0256	0.0250	0.0234	123	0.0093	0.0090	0.0085
202	0.0418	0.0408	0.0382	162	0.0252	0.0246	0.0231	122	0.0089	0.0087	0.0081
201	0.0413	0.0404	0.0379	161	0.0248	0.0242	0.0227	121	0.0084	0.0083	0.0078
200	0.0409	0.0400	0.0375	160	0.0244	0.0238	0.0223	120	0.0080	0.0079	0.0074
199	0.0405	0.0396	0.0371	159	0.0239	0.0234	0.0219	119	0.0076	0.0075	0.0070
198	0.0401	0.0392	0.0367	158	0.0234	0.0230	0.0216	118	0.0072	0.0071	0.0067
197	0.0397	0.0388	0.0363	157	0.0230	0.0226	0.0212	117	0.0068	0.0067	0.0063
196	0.0392	0.0384	0.0360	156	0.0226	0.0222	0.0208	116	0.0064	0.0063	0.0059
195	0.0388	0.0379	0.0356	155	0.0222	0.0218	0.0204	115	0.0060	0.0059	0.0056
194	0.0384	0.0375	0.0352	154	0.0218	0.0214	0.0200	114	0.0056	0.0055	0.0052
193	0.0380	0.0371	0.0348	153	0.0214	0.0210	0.0197	113	0.0052	0.0051	0.0048
192	0.0375	0.0367	0.0344	152	0.0210	0.0206	0.0193	112	0.0048	0.0047	0.0044
191	0.0371	0.0363	0.0341	151	0.0206	0.0202	0.0189	111	0.0044	0.0043	0.0041
190	0.0367	0.0359	0.0337	150	0.0202	0.0198	0.0186	110	0.0040	0.0039	0.0037
189	0.0363	0.0355	0.0333	149	0.0198	0.0194	0.0182	109	0.0036	0.0035	0.0033
188	0.0359	0.0351	0.0329	148	0.0194	0.0190	0.0178	108	0.0032	0.0031	0.0030
187	0.0355	0.0347	0.0325	147	0.0189	0.0186	0.0174	107	0.0028	0.0027	0.0026
186	0.0351	0.0343	0.0322	146	0.0186	0.0182	0.0170	106	0.0024	0.0023	0.0022
185	0.0347	0.0339	0.0318	145	0.0182	0.0178	0.0167	105	0.0020	0.0020	0.0018
184	0.0343	0.0335	0.0314	144	0.0177	0.0174	0.0163	104	0.0016	0.0016	0.0015
183	0.0339	0.0331	0.0310	143	0.0173	0.0170	0.0159	103	0.0012	0.0012	0.0011
182	0.0334	0.0327	0.0306	142	0.0169	0.0166	0.0155	102	0.0008	0.0008	0.0007
181	0.0330	0.0323	0.0303	141	0.0165	0.0162	0.0152	101	0.0004	0.0004	0.0004
								100	0.0000	0.0000	0.0000

The portion of the table below should not be used unless the oil is entirely free from crystals.

Observed Temperature, deg. Fahr.	Subtract from Observed Specific Gravity			Observed Temperature, deg. Fahr.	Subtract from Observed Specific Gravity			Observed Temperature, deg. Fahr.	Subtract from Observed Specific Gravity		
	Creosote	Solution	Coal Tar		Creosote	Solution	Coal Tar		Creosote	Solution	Coal Tar
99	0.0004	0.0004	0.0004	84	0.0063	0.0062	0.0059	69	0.0122	0.0121	0.0113
98	0.0008	0.0008	0.0007	83	0.0067	0.0066	0.0063	68	0.0126	0.0124	0.0117
97	0.0012	0.0012	0.0011	82	0.0071	0.0070	0.0066	67	0.0130	0.0128	0.0120
96	0.0016	0.0016	0.0015	81	0.0075	0.0074	0.0070	66	0.0134	0.0132	0.0124
95	0.0020	0.0020	0.0018	80	0.0079	0.0078	0.0074	65	0.0138	0.0136	0.0128
94	0.0024	0.0023	0.0022	79	0.0083	0.0082	0.0077	64	0.0142	0.0140	0.0132
93	0.0028	0.0027	0.0026	78	0.0087	0.0086	0.0081	63	0.0146	0.0144	0.0135
92	0.0032	0.0031	0.0030	77	0.0091	0.0090	0.0085	62	0.0150	0.0148	0.0139
91	0.0036	0.0035	0.0033	76	0.0095	0.0094	0.0088	61	0.0154	0.0152	0.0143
90	0.0040	0.0039	0.0037	75	0.0099	0.0097	0.0092	60	0.0158	0.0155	0.0146
89	0.0043	0.0043	0.0040	74	0.0103	0.0101	0.0096				
88	0.0047	0.0047	0.0044	73	0.0107	0.0105	0.0099				
87	0.0051	0.0051	0.0048	72	0.0111	0.0109	0.0102				
86	0.0055	0.0055	0.0052	71	0.0115	0.0113	0.0106				
85	0.0059	0.0058	0.0055	70	0.0118	0.0117	0.0109				

A.R.E.A METHOD OF TEST FOR
WATER IN CREOSOTE

AMERICAN ASSOCIATION STATE
HIGHWAY OFFICIALS STANDARD
A.A.S.H.O. NO.: T 83

Standard Method of Test for

WATER IN CREOSOTE[1]

ASTM Designation: D 370 – 58

Adopted, 1933; Revised, 1958.

This Standard of the American Society for Testing Materials is issued under the fixed designation D 370; the final number indicates the year of original adoption as standard or, in the case of revision, the year of last revision.

Note.—This method was editorially revised and rearranged in 1939. Further editorial changes were included in 1955.

Scope

1. This is an accurate method for determining the percentage of water in creosote and creosote - coal tar solution. Its use is indicated for dehydrating creosote containing more than 3 per cent of water in preparation for the distillation test. The alternative procedure is more convenient and rapid where the determination of water only is required.

Apparatus

2. (*a*) *Still.*—A vertical, cylindrical copper still, with removable flanged top and yoke, of the form and approximate dimensions shown in Fig. 1.

(*b*) *Thermometer.*—An ASTM High Distillation Thermometer, total immersion, graduated in either Centigrade or Fahrenheit degrees as specified, having a range of −2 to +400 C or 30 to 760 F, and conforming to the requirements for thermometer 8C – 42 as prescribed in ASTM Specifications E 1.[2]

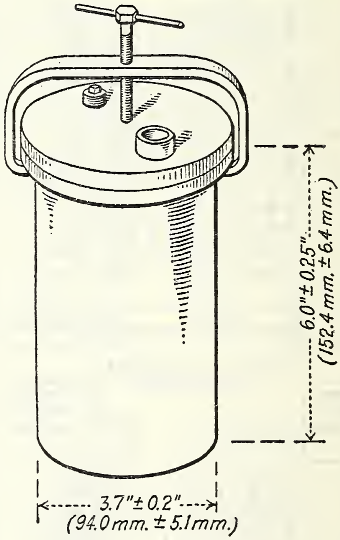

Fig. 1.—Copper Still.

(*c*) *Condenser.*—A copper trough condenser, with straight-walled glass tube, having approximately the form and dimensions shown in Fig. 2.

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[1] Under the standardization procedure of the Society, this method is under the jurisdiction of the ASTM Committee D-7 on Wood.

This method is substantially in agreement with the Standard Method for the Determination of Water in Creosote which is part of the American Wood Preservers' Association Standard Methods for Analysis of Creosote (A1–54).

[2] 1958 Book of ASTM Standards, Parts 4 and 7.

(*d*) *Separatory Funnel.*—A separatory funnel conforming to the requirements shown in Fig. 3. It shall have a total capacity of approximately 200 ml, with the lower 20 ml graduated accurately in 0.1 ml. The graduation marks shall be numbered for each milliliter.

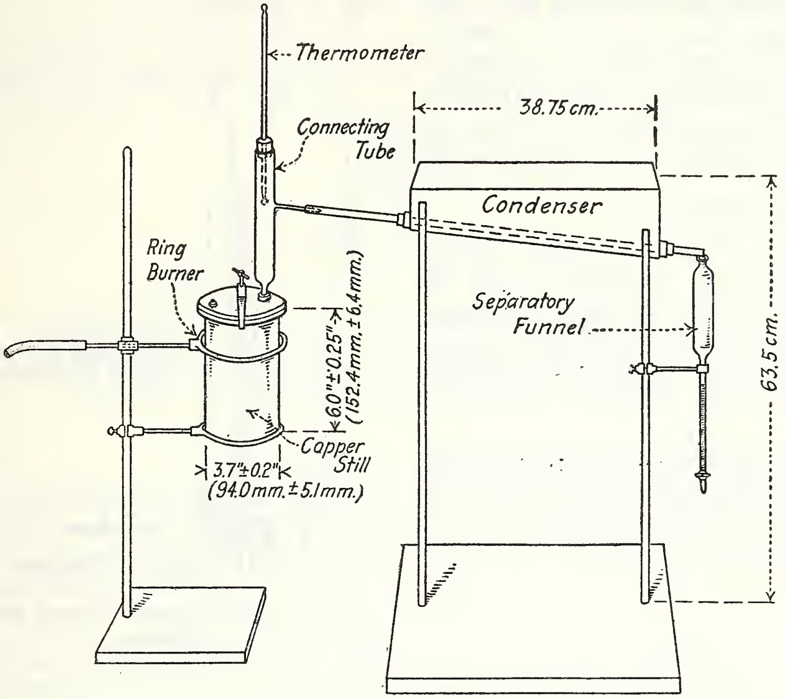

FIG. 2.—Assembled Apparatus for Water Test.

Apparatus Assembly

3. The apparatus shall be assembled as shown in Fig. 2.

Procedure

4. (*a*) When any measurable amount of water is present in the distillate below 210 C as determined in accordance with the Standard Method of Test for Distillation of Creosote (ASTM Designation: D 246),[3] the oil and water in this fraction shall be separated, if possible, and measured separately. If more than 3 per cent of water is present, the percentage of water present shall be determined by the method described in Paragraph (*b*), and the water-free oil so obtained shall be used in the distillation test.

(*b*) Measure a 200-ml sample of the oil into a graduated cylinder and pour into a copper still, allowing the cylinder to drain into the still for several minutes. Clamp the lid on, using a paper gasket slightly wet with oil around the flange of the still. Apply heat by means of the ring burner, which shall be placed just above the level of the oil in the still at the beginning of the test and gradually lowered when most of the water has distilled over. Continue the distillation until the vapor temperature reaches

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[3] See p. 254.

205 C, as indicated by the thermometer with the bulb opposite the off-take of the connecting tube. Collect the distillate in a separatory funnel. When the distillation is completed, and a clear separation of water and oil in the funnel has taken place, read the water by volume and draw it off. Return any light oil distilled over with the water to the oil in the still. The dehydrated oil from the still shall be used for the distillation test.

Alternative Procedure

5. The amount of water may be determined in accordance with the Method of Test for Water in Petroleum Products and Other Bituminous Materials (ASTM Designation: D 95).[2]

NOTE.—Method D 95 is the preferred Method where the determination of the water only is desired and the dehydrated material is not to be used subsequently for analysis.

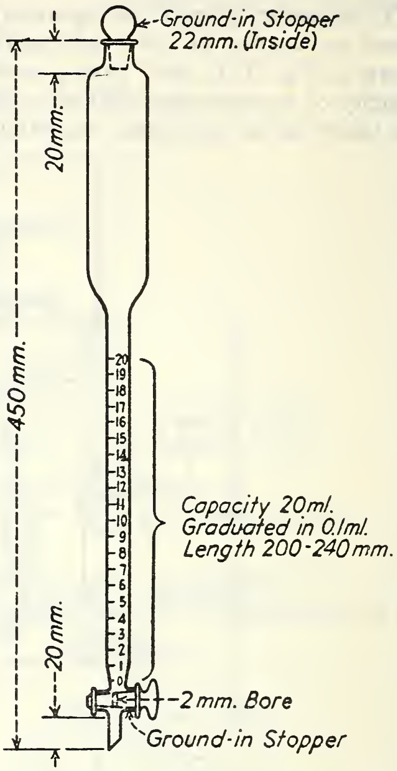
Ground-in Stopper 22 mm. (Inside)
20 mm.
450 mm.
20
19
18
17
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
Capacity 20 ml. Graduated in 0.1 ml. Length 200-240 mm.
20 mm.
2 mm. Bore
Ground-in Stopper

FIG. 3.—Glass Separatory Funnel, 200-ml Capacity.

Tentative Method of Test for

WATER AND SEDIMENT BY MEANS OF CENTRIFUGE[1]

ASTM Designation: D 96 - 58 T

Issued, 1947; Revised, 1950, 1952, 1957, 1958.[2]

This Tentative Method has been approved by the sponsoring committee and accepted by the Society in accordance with established procedures, for use pending adoption as standard. Suggestions for revisions should be addressed to the Society at 1916 Race St., Philadelphia 3, Pa.

Scope

1. This method describes a procedure for the determination of water and sediment in crude mineral oils and fuel oils by means of the centrifuge.

Note 1.—A centrifuge method for determining water and sediment is not entirely satisfactory because the amount of water obtained is nearly always lower than the actual water content. Nevertheless, on account of the wide use of the centrifuge for this purpose, it is desirable that the method of making the determination be standardized as far as possible. It must be clearly understood that the total volume as read from the centrifuge tube includes both the sediment and the precipitated water. Accurate determination of water content, if desired, should be made in accordance with Method D 95, Test for Water in Petroleum Products and Other Bituminous Materials.[3]

Apparatus

2. (*a*) *Centrifuge*, capable of whirling two or more filled centrifuge tubes at a speed which can be controlled to give a relative centrifugal force (rcf) of between 500 and 800 at the tip of the tubes. The revolving head, trunnion rings and trunnion cups, including the cushion, shall be soundly constructed to withstand the maximum centrifugal force capable of being delivered by the power source. The trunnion cups and cushions shall firmly support the tubes when the centrifuge is in motion. The centrifuge shall be enclosed by a metal shield or case strong enough to eliminate danger if any breakage occurs. Calculate the speed of the rotating head as follows:

$$\text{rpm} = 265 \sqrt{\frac{\text{rcf}}{d}}$$

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[1] Under the standardization procedure of the Society, this method is under the jurisdiction of the ASTM Committee D-2 on Petroleum Products and Lubricants.

[2] Latest revision accepted by the Society at the Annual Meeting, June, 1958.

Prior to its present publication as tentative, this method was published as tentative from 1921 to 1924, being revised in 1924. It was adopted in 1924 and published as standard from 1924 to 1947, being revised in 1928, 1930, 1935, 1940, 1946, and 1947.

In 1958, Section 4(*a*) was changed to specify the use of benzene saturated with water at ambient temperature.

[3] 1958 Book of ASTM Standards, Parts 5 and 7.

where:

rcf = relative centrifugal force, and
d = diameter of swing, in inches, measured between tips of opposite tubes when in rotating position.

(*b*) *Centrifuge Tube,* pear-shaped or cone-shaped, conforming to dimensions given in Figs. 1 and 2, respectively, and made of thoroughly-annealed glass. The graduations, numbered as shown in Figs. 1 and 2, shall be clear and distinct, and the mouth constricted in shape for closure with a cork. Scale error tolerances and smallest graduations between various calibration marks are given in Tables I and II, and apply to calibrations made with air-free water at 20 C.

(*c*) *Bath.*—The bath shall be either a solid metal block bath or a liquid bath of sufficient depth for immersing the centrifuge tube in a vertical position to the 100-ml mark. Means shall be provided for maintaining temperatures at 120 ± 2 F (49 ± 1 C) and 140 ± 2 F (60 ± 1 C).

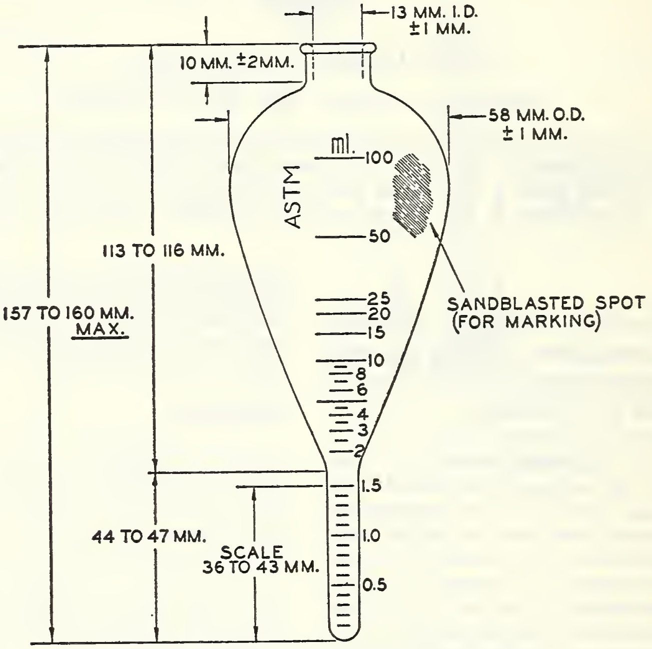

Fig. 1.—ASTM Pear-Shaped Centrifuge Tube.

TABLE I.—PEAR-SHAPED CENTRIFUGE TUBE CALIBRATION TOLERANCES.

Range, ml	Smallest Scale Division, ml	Maximum Scale Error, ml
0 to 1.5	0.1	0.03
Over 1.5 to 3.0	0.5	0.20
Over 3.0 to 5.0	0.5	0.30
Over 5.0 to 10.0	1	0.50
Over 10 to 25	5	1.0
Over 25 to 100	25	2.0

TABLE II.—CONE-SHAPED CENTRIFUGE TUBE CALIBRATION TOLERANCES.

Range, ml	Smallest Scale Division, ml	Maximum Scale Error, ml
0 to 0.1	0.05	0.02
Over 0.1 to 0.3	0.05	0.03
Over 0.3 to 0.5	0.05	0.05
Over 0.5 to 1.0	0.1	0.05
Over 1.0 to 2.0	0.1	0.10
Over 2.0 to 3.0	0.2	0.10
Over 3.0 to 5.0	0.5	0.20
Over 5.0 to 10.0	1	0.50
Over 10 to 25	5	1.0
Over 25 to 100	25	1.0

Sample

3. The sample shall be thoroughly representative of the material in question and the portion used for the test shall be thoroughly representative of the sample itself. This requires vigorous agitation of the sample immediately before transferring the sample to the tube. The difficulties in obtaining representative samples for this determination are unusually great; hence, the importance of sampling cannot be too strongly emphasized.

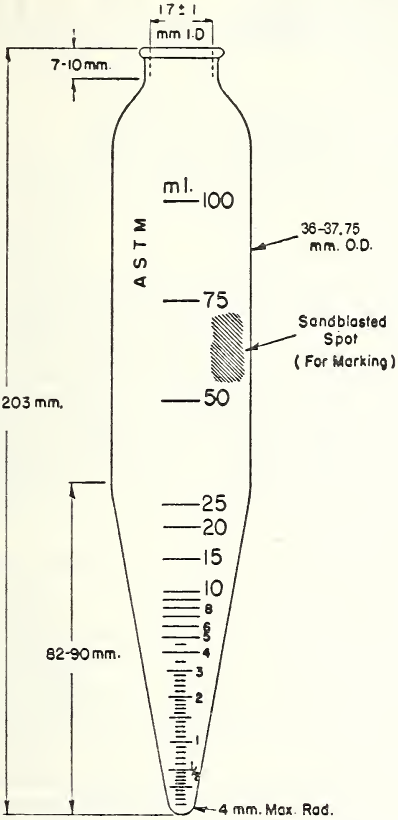

Fig. 2.—ASTM Cone-Shaped Centrifuge Tube.

Procedure

4. (*a*) Measure exactly 50 ml of industrial benzene (ASTM Designation: D 837)[4], saturated with water at ambient temperature, into the centrifuge tube and add exactly 50 ml of the oil to be tested. Stopper the tube tightly and shake vigorously until the contents are thoroughly mixed. Immerse the tube to the 100-ml mark for 10 min in the bath maintained at 120 ± 2 F (49 ± 1 C).

Note 2.—If wax contributes to the volume of water and sediment observed, preheat the oil-benzene mixture to 140 F (60 C) before each whirling; the final temperature of the oil-benzene mixture shall not drop below 115 F (46 C).

(*b*) Shake the tube vigorously for 10 sec, place in a trunnion cup opposite another filled tube to establish a balanced condition, and whirl for 10 min at a rate, calculated from the equation in Section 2 (*a*), sufficient to produce a relative centrifugal force (rcf) of between 500 and 800 at the tip of the whirling tubes (see Table III for the relationship between diameter of swing, rcf, and rpm). Read and record the combined volume of water and sediment at the bottom of the tube to the nearest 0.05 ml from 0 to 1 ml graduation and to the nearest 0.1 ml above 1 ml graduation. Return the tube to the centrifuge and whirl for 10 min at the same rate. Repeat this operation

TABLE III.—ROTATION SPEEDS APPLICABLE FOR CENTRIFUGES OF VARIOUS DIAMETERS OF SWING.

Diameter of Swing, in.[a]	Rpm at 500 rcf	Rpm at 800 rcf
12	1710	2160
13	1650	2080
14	1590	2000
15	1530	1930
16	1480	1870
17	1440	1820
18	1400	1770
19	1360	1720
20	1330	1680
21	1300	1640
22	1270	1600
23	1240	1560
24	1210	1530

[a] Measured in inches between tips of opposite tubes when in rotating position.

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[4] 1958 Book of ASTM Standards, Part 8.

until the combined volume of water and sediment remains constant for two consecutive readings. In general, not more than two whirlings are required.

Water and Sediment

5. Read the combined volume of water and sediment as directed in Section 4 (*b*), multiply by two, and record the result as the percentage of water and sediment, centrifuge method.

Precision

6. Results should not differ by more than the following percentages:

Water and Sediment, per cent	Repeatability (One Operator and One Apparatus)	Reproducibility (Different Operators and Apparatus)
0 to 0.5........	0.1	0.2
Over 0.5 to 1.5.......	0.2	0.4
Over 1.5 to 3.0.......	0.2	0.6

Tentative Method of Testing

WOOD PRESERVATIVES BY LABORATORY SOIL-BLOCK CULTURES[1]

ASTM Designation: D 1413 – 56 T

Issued, 1956.[2]

This Tentative Method has been approved by the sponsoring committee and accepted by the Society in accordance with established procedures, for use pending adoption as standard. Suggestions for revisions should be addressed to the Society at 1916 Race St., Philadelphia 3, Pa.

Scope

1. (*a*) This method is intended for determining the relative fungicidal value of wood preservatives by means of laboratory soil-block cultures.

(*b*) The requirements for preparation of the material for testing and the test procedures appear in the following order:

	Sections
Outline of Method	2
Apparatus	3
Reagents	4
Test Specimens	5
Test Fungi	6
Culture Media	7
Preparation of Test Cultures	8
Preparation and Impregnation of Test Blocks	9
Conditioning Treated Blocks	10
Preservative Permanence; Weathering Procedure	11
Infection of Test Blocks	12
Incubation and Duration of Test	13
Handling Test Blocks after Exposure to Test Fungi	14
Calculation of Weight Losses	15
Evaluation of Test Results	16
Refining the Threshold	17
Report	18

Outline of Method

2. Blocks of wood are impregnated with an appropriate series of gradient concentrations of a preservative; and, after selected periods of conditioning or weathering, they are exposed to the action of one or more wood-destroying fungi. The minimum amount of preservative that completely protects the impregnated blocks against decay by a given test fungus is defined as the threshold retention for that organism. The failure to protect is determined by the amount of weight loss in the treated wood block.

Apparatus

3. (*a*) *Conditioning Room*, with regulating instruments for controlling temperature at 26.7 ± 1.1 C (80.0 ± 2.0 F) and a relative humidity at 70 ± 4 per cent.[3]

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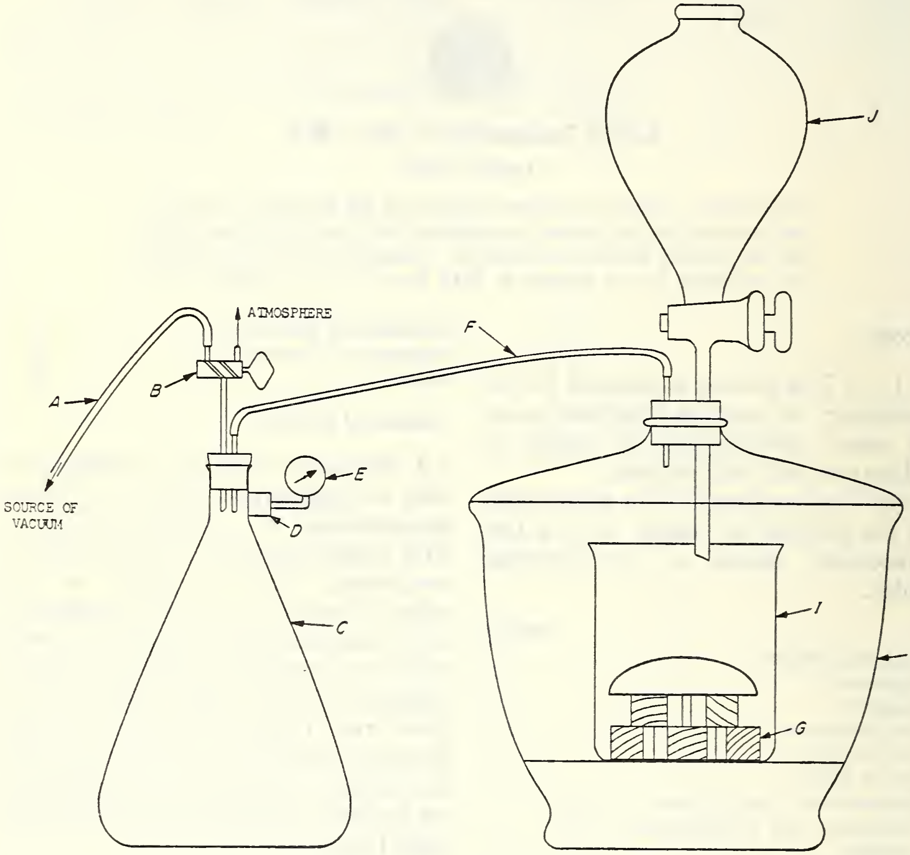
[1] Under the standardization procedure of the Society, this method is under the jurisdiction of the ASTM Committee D-7 on Wood.

[2] Accepted by the Society at the Annual Meeting, June, 1956.

[3] T. C. Scheffer, "Humidity Controls for Conditioning Rooms," *Forest Products Laboratory Report No. 2048*, U. S. Forest Service, 4 pp., 5 figs., January, 1956.

(*b*) *Incubation Room*, or incubation cabinets controllable to the same temperature and relative-humidity conditions as those specified for the conditioning room (Paragraph (*a*)).



A—Line to source of vacuum.
B—Vacuum-line stopcock.
C—Filter-flask trap.
D—Connection for vacuum gage or manometer.
E—Vacuum gage.
F—Line to bell jar or vacuum desiccator.
G—Test cubes covered by glass weight.
H—Vacuum desiccator or bell jar.
I—Treatment beaker.
J—Separatory funnel.

FIG. 1.—Assembly for Treating Chamber.

(*c*) *Drying Oven*, hot air, controllable for temperatures from 90 to 107 C (194 to 225 F).

(*d*) *Autoclave.*

(*e*) *Balances*, torsion or direct-reading types preferred, sensitive to 0.01 g.

(*f*) *Vacuum Pump* (or water suction pump), for reducing pressure to not more than 10 cm of mercury.

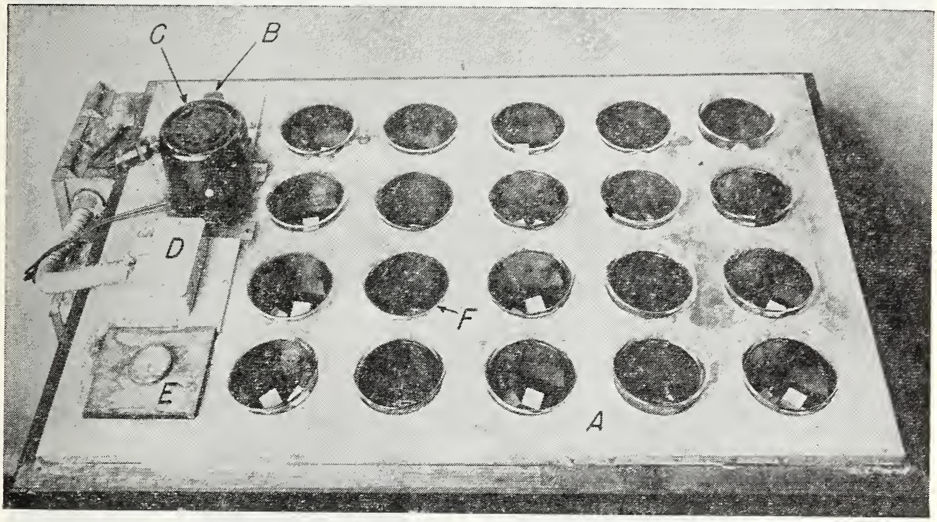
(*g*) *Impregnating Apparatus*, consisting of a suitable desiccator or bell jar, fitted with appropriate vents and stopcocks for connection to the vacuum pump and to a manometer or pressure gage, and with a separatory funnel for holding the preservative (Fig. 1).

(*h*) *Trays or Racks*, for convenient handling of the test blocks.

(*i*) *Weathering Box*, with controlled temperature water bath (Fig. 2).

(*j*) *Culture Bottles*, cylindrical or French square (Note 1), capacity 237 ml (8 oz), fitted with screw caps (without liners) (Fig. 3).

Note 1.—If the French square bottles are used, set up the apparatus with one test block in each bottle; if the cylindrical bottles are used, either one block or two blocks of the same retention group may be used. In the two-block arrangement the blocks shall be placed so that they do not touch each other.



A—Box containing a tank, 1.5 by 2.5 by 1 ft deep, surrounded by 2 in. of glass-wool insulation. Control instruments and beakers for holding test specimens are suspended through holes in the metal cover of the box.
B—Thermostat for the control of temperature of the water bath (to give the standard temperature in test blocks of 120 F (48.9 C)).
C—Pump, driven by $\frac{1}{30}$-hp fan-cooled motor, for circulating water.
D—Heater, immersion type, 2000-w, 220-v.
E—Thermometer to indicate temperature of water bath.
F—Pyrex beaker, 600-ml capacity and 4½ in. deep, containing six similarly treated test specimens spaced on a screen ½ in. above the bottom (all standard features).

Fig. 2.—A Weathering Box.

Reagents

4. (*a*) *Toluene*, conforming to Specifications for Nitration Grade Toluene (ASTM Designation: D 841).[4]

(*b*) *Distilled Water*, conforming to Specifications for Reagent Water (ASTM Designation: D 1193).[5]

Test Specimens

5. (*a*) *Species of Wood.*—Southern pine sapwood, free from knots and excessive resins, and showing no visible evidence of infection by mold, stain, or wood-destroying fungi, with four to ten rings per inch, shall be used for standard comparative tests. Any sapwood or any heartwood may be used for special investigations, but the test blocks shall be all sapwood or all heartwood in any given comparative series. The same species of wood shall be used in any test designed to furnish data on relative

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[4] 1958 Book of ASTM Standards, Part 8.

[5] 1958 Book of ASTM Standards, Parts 7 and 10.

fungicidal value of any given preservatives.

When the boundary between heartwood and sapwood is difficult to recognize, a color test[6] should be used, when possible, to distinguish between the two. Uneven absorptions are caused by the presence of heartwood, and heartwood is not sufficiently uniform in susceptibility to decay. Whenever practicable, the selection of wood for the test blocks should begin in the woods or at the sawmill. Quarter-sawing is preferable. It is desirable that the selected freshly-cut boards—nominally 2.5 cm (1.0 in.) thick—be kiln dried directly from the saw in order to avoid all chance of fungus infection or deterioration before and during shipment. The kiln-dried boards shall be stored flat in a dry room where they may come to an equilibrium moisture content of about 10 to 12 per cent (oven-dry basis). The exact procedure for planing and cutting up the boards depends on the available equipment.

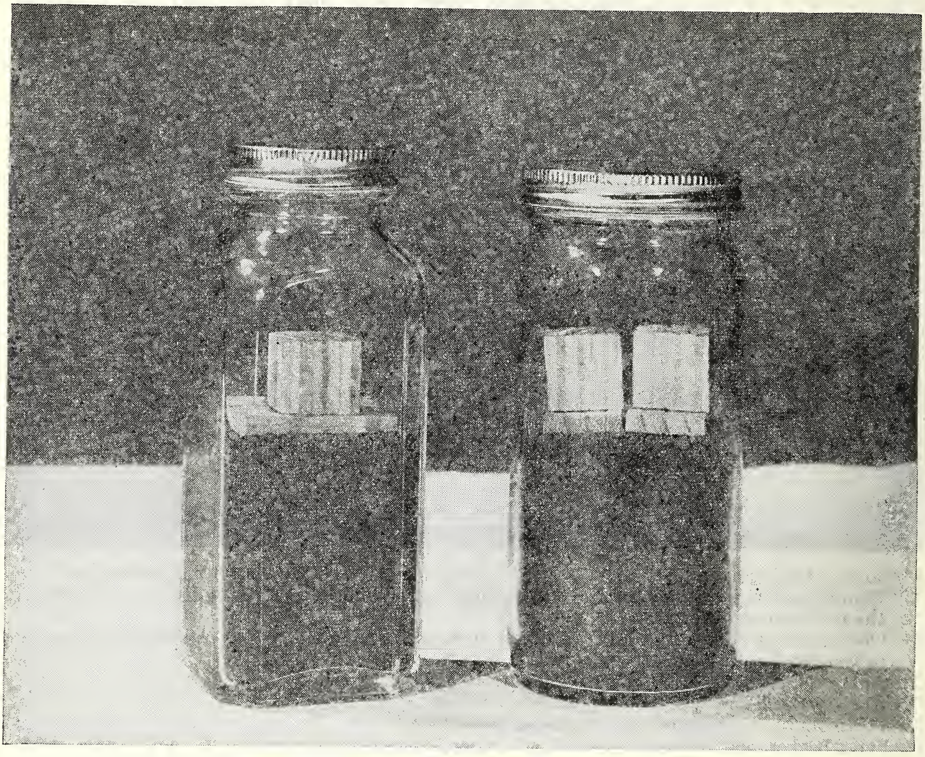

FIG. 3.—French Square and Cylindrical 8-oz Culture Bottles, with Metal Screw Caps, Showing Setup of Soil, Feeder Blocks, and Test Blocks for Each Type of Bottle.

(*b*) *Test Blocks.*—The test blocks shall be cubes milled as accurately as possible to 1.9 cm (0.75 in.). If necessary (for example, for convenience in handling), blocks may be drilled through the center of a tangential face with a 0.32-cm ($\frac{1}{8}$-in.) drill. The volume of the blocks without the hole should be approximately 6.9 cu cm (0.42 cu in.), and of the blocks with the hole approximately 6.8 cu cm (0.41 cu in.).

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[6] "Color Tests for Differentiating Heartwood and Sapwood of Certain Oaks, Pines and Douglas-Fir," *Forest Products Laboratory Technical Note 253*, U. S. Forest Service, revised June, 1954.

NOTE 2.—Working stocks of test blocks and feeder blocks shall be stored under dry conditions. It is desirable to weigh the blocks after they come to approximate equilibrium moisture content in storage or in the conditioning room, and to sort them into fairly narrow-range weight groups. Since the blocks are to be cut accurately to size this division into weight groups is in effect a segregation into density groups (see Section 9(*d*)).

(*c*) *Feeder Blocks.*—The feeder blocks shall preferably be cut from quarter-sawed stock in approximately either of the following two sizes, with the long axis of the blocks parallel with the grain of the wood:

Size No.	
1	0.3 by 2.9 by 4.1 cm ($\frac{1}{8}$ by $1\frac{1}{8}$ by $1\frac{5}{8}$ in.)
2	0.4 by 1.9 by 3.5 cm ($\frac{5}{32}$ by $\frac{3}{4}$ by $1\frac{3}{8}$ in.)

Size No. 1 feeder block is to be used in the French square bottle and with one impregnated test block as shown in Fig. 3. Size No. 1 feeder block also may be used with one impregnated test block in the cylindrical test bottle. If two blocks of the same retention group are placed in the cylindrical test bottles, size No. 2 feeder blocks shall be used.

If test blocks other than southern pine are used, the sapwood selected for feeder blocks shall be capable of furnishing a satisfactory growth of the test fungus; for instance, sweet-gum sapwood is often used with hardwood test blocks and *Polyporus versicolor* L. ex Fr.

Test Fungi

6. (*a*) *For Softwood Sapwoods:*

(*1*) *Lentinus lepideus* Fr. (Madison 534) (Note 3), particularly tolerant to creosote or mixtures containing creosotes,

(*2*) *Lenzites trabea* Pers. ex Fr. (Madison 617), particularly tolerant to phenolic and arsenic compounds, and

(*3*) *Poria monticola* Murr. (Madison 698), particularly tolerant to copper and zinc compounds, also suggested for mercury compounds.

NOTE 3.—Numbers refer to standard strains of the test fungi maintained in the American Type Culture Collection, 2029 M St., N. W., Washington, D. C.

(*b*) *For Hardwood Sapwoods.*—The three fungi listed in Paragraph (*a*), and *Polyporus versicolor* L. ex Fr. (Madison 697).

(*c*) The tolerant fungus shall always be included in testing any given preservative. Other economically important fungi may be substituted for the nontolerant organisms in special investigations.

Culture Media

7. (*a*) *Malt Agar Substrate.*—A malt agar medium (or satisfactory equivalent) shall be used for the stock test-tube cultures and for petri-dish cultures of the test fungi. This medium shall be sterilized at 15 psi for 20 min.

(*b*) *Soil Substrate.*—The soil substrate should fill the culture bottles about half full. A soil with a water-holding capacity between 20 and 40 per cent and pH between 5.0 and 7.0 shall be used. A measured volume of 100 ml of the sifted air-dry soil, lightly compacted by tapping, shall weigh not less than 90 g. The soil shall be mixed after breaking up all clumps, sifted through a No. 6 sieve, and stored in large covered containers. The soil should not be so wet when it is sifted that the particles again stick together.

NOTE 4.—The water-holding capacity of a soil shall be considered as that percentage of water, based on the oven-dry weight of the soil, that is retained after subjecting the soil to the following procedure:[7]

Fill a small Büchner funnel, approximately 5 cm in diameter and 2.5 cm in depth, and fitted with a No. 613 "E and D" filter paper, to somewhat more than capacity with air-dry soil previously passed through a 2-mm sieve. Compact the soil by dropping the funnel three times through a height of 1 cm on a wooden table top. Level the soil surface with a spatula. Then place the filled funnel in a 400-ml beaker and retain in an upright position by wedges at the sides of the funnel. Add water to the beaker to a depth slightly beyond the level of the filter paper. Allow the soil to wet by capillarity so as to reduce the danger of entrapping air within the column. When the upper soil surface shows signs of wetting, add more water until the water level approximates the upper surface of the funnel. Place a cover over the beaker, and allow the soil to soak for 12 hr or overnight. Then place the funnel in a suction flask which is connected to a water aspirator or vacuum pump, and apply full suction for 15 min. During suctioning, cover the funnel with a moist cloth on which an inverted cup is placed. After 15 min remove the funnel from the suction flask, scrape the soil into a weighed receptacle, and determine its moisture content.

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[7] The method is essentially that of G. J. A. Bouyoucos, "A Comparison Between the Suction Method and the Centrifuge Method for Determining the Moisture Equivalent of Soils," *Soil Science*, Vol. 40, pp. 165–70 (1935).

The percentage of water in the completed test bottle shall be 130 per cent of the water-holding capacity of the soil. To arrive at this, determine the percentage of moisture in the stock soil and the grams of soil needed to fill the culture bottle half full (the standard volume). Make both of these determinations on an oven-dry basis. Put the difference, in milliliters of distilled water, between the moisture in the stock soil and the final amount needed, into each bottle. Then add the standard volume of soil to the test bottle. Level the soil surface, and place a sapwood feeder block (or blocks) directly on the soil. Sterilize the prepared bottles, with caps loosened, at 15 psi for 30 min.

NOTE 5.—The sequence indicated above in Note 4—first the water, and then the soil—leaves clean inside-bottle surfaces above the soil level as a general rule. The water diffuses through the soil during sterilization.

Preparation of Test Cultures

8. (*a*) After the sterilized culture bottles are thoroughly cooled, cut the fungus inoculum, approximately 1 cm square, from a not more than 3-week-old petri-dish culture and place in contact with an edge of a feeder block. Incubate the inoculated bottles, with lids released one-fourth turn from a tightened position, at 26.7 ± 1 C (80.0 ± 2.0 F) and 70 ± 4 per cent relative humidity for approximately 3 weeks, or until the feeder blocks are covered by mycelium. The bottles are then ready to receive the test blocks.

(*b*) Provision shall be made for coordinated and timed preparation of the test cultures and for impregnation, conditioning, or weathering and conditioning of the test blocks.

Preparation and Impregnation of Test Blocks

9. (*a*) *Initial Conditioning and Initial Weights.*—Condition the test blocks for treatment by either of the two following methods:

(*1*) *Conditioning at Specified Temperature and Relative Humidity.*—Bring the test blocks to a constant moisture equilibrium in the conditioning room. After suitable labeling (for example, with waterproof India ink) weigh the blocks to the nearest 0.01 g. This weight is referred to as the initial or untreated weight of the block (T_1), and shall be maintained until the blocks are impregnated (see Note 8).

(*2*) *Oven-drying.*—Dry the labeled blocks at 105 ± 2 C (221 ± 3.6 F) for 24 hr. Then weigh the blocks to the nearest 0.01 g. This weight shall be considered as the initial or untreated weight of the block (T_1). Keep the oven-dried blocks over phosphorus pentoxide in an appropriate desiccator until impregnated.

(*b*) *Concentration of Preservatives in Treating Solutions.*—The treating solutions shall be made up in appropriate gradient concentrations with a view to leaving in the blocks at treatment a range of retentions running from below to above an anticipated threshold. The lowest retention shall be low enough to permit fungus attack and consequent decay and definite weight loss. When the preservative is soluble in water the required concentrations shall be made up with distilled water. Preservatives that are insoluble in water, such as creosotes, creosote-coal tar solutions, and solutions of pentachlorophenol or copper naphthenate in an oil carrier, shall be diluted with toluene. The dilutions are necessary to provide a uniform distribution of preservative at retentions low enough to permit determination of threshold values for the various test fungi employed. All preservatives shall be in such a state of solution before use that the active ingredients will be uniformly distributed throughout the treated wood. The number of concentrations to be made up for any given preservative depends on whether it is possible to anticipate a threshold and how close it is necessary to determine it. The preferred procedure is to run a preliminary or reconnaissance test to locate the threshold approximately, and then to run a critical series of tests, narrowing the interval in the concentration around the level of the anticipated threshold.

(c) *Number of Blocks in a Treatment Group.*—The number of blocks to be treated with a given concentration of preservative, for testing by a particular fungus, may vary. Usually, it is desirable to treat enough blocks to prepare no less than four test bottles. The smaller the interval between concentrations of treating solution, the smaller the number required. The primary concern shall be to see that the number of blocks is sufficient to define clearly the relation between preservative retention and weight change in the blocks during test.

(d) *Treatment Procedure.*—It is desirable to choose blocks for treatment that have the narrowest practicable spread in density; for example, weight differences not exceeding 0.5 g among blocks in a given test should be attainable. Place in a beaker the blocks to be treated with a given concentration of preservative, and weight them down to prevent floating. Place the beaker in a treating chamber such as a desiccator or bell jar, attach to a vacuum pump and to a manometer or pressure gage (Fig. 1). Reduce the pressure in the treating chamber until it is not more than 10 cm of mercury and hold for 20 to 30 min. Pour the solution of a given preservative into a separatory funnel, with the stem extending through the top of the treating chamber and into the beaker containing the blocks. Turn off the vacuum pump and open the separatory funnel stopcock to let the solution run directly into the beaker in the evacuated chamber. Use sufficient solution so that the blocks will remain completely covered after the vacuum is cut off. Then remove the beaker from the treating chamber and cover tightly to prevent loss of treating solution by evaporation. Leave the blocks submerged in the treating solution for at least 30 min. A longer time may be necessary for some treating solutions in order to obtain maximum and uniform absorptions (Note 6) in the blocks. Remove the blocks from the solution individually, wipe lightly to remove surface preservative solution, and immediately weigh to the nearest 0.01 g (T_2) (see Note 8). Record the gain in weight ($T_2 - T_1$) as the grams of treating solution absorbed.

NOTE 6.—Values in the test are based on equal distribution of the preservative in the wood. Such distribution is obtained only if the absorptions represent the total amount of liquid a block will hold. The air has been evacuated from the wood, leaving the cell cavities free to be filled with the preservative solution. The amount of air spaces available to hold liquids has been determined[8] for woods of different density and moisture content. Therefore, the approximate maximum absorption to be expected can be computed from the percentage of air space and the specific gravity of the treating solution. The greater the volume of air space (the lower the density), the greater the absorption that should be obtained if all air cavities are filled. With water-soluble preservatives, absorptions are higher than for oil-type preservatives because water not only fills the air spaces but is also absorbed in the cell wall.

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[8] J. D. MacLean, "Effect of Moisture Changes on the Shrinkage, Swelling, Specific Gravity, Air or Void Space, Weight, and Similar Properties of Wood," *Mimeographed Report No. 1448, U. S. Department of Agriculture* (1952).

(*e*) *Calculation of Retentions.*—Calculate the amount of preservative absorbed by the block, or retention, as pounds per cubic foot as follows:

$$\text{Retention, lb per cu ft} = \frac{GC(62.4)}{100V}$$

where:

G = $(T_2 - T_1)$ = grams of treating solution absorbed by the block (initial weight of block subtracted from the initial weight plus the treating solution absorbed),
C = grams of preservative or preservative solution in 100 g of treating solution,
V = volume of block in cubic centimeters, and
62.4 = factor for converting grams per cubic centimeter to pounds per cubic foot.

(*f*) *Untreated Control Blocks.*—Run at least five untreated control blocks, of density comparable to the test blocks, through all the steps of the test procedure for each fungus. Since these control blocks are carried through the decay test, the amount of weight loss caused in them by the various test organisms serves as a check on the normalcy of the individual tests and on the stability of test conditions from run to run. The control blocks also are needed as a guide to possible weight corrections necessary in calculating the residual preservative in the treated blocks following conditioning, or weathering and conditioning (Note 7).

NOTE 7.—The amount of preservative remaining in a block after conditioning, or weathering and conditioning, is calculated through the T_1 and T_3 or T_{3w} weights (see Note 8), and sometimes also through the corresponding weights of the control blocks, which may be designated X_1 and X_3, or X_{3w}. A change in the control-block weights signifies a change in the moisture content of the wood. A similar change is presumed to have occurred in the treated blocks. Therefore, the weight losses in the treated blocks should be corrected for any significant moisture changes indicated by the control blocks, if the most reliable estimate of residual preservative is to be made (see Table I in the Appendix).

Conditioning Treated Blocks

10. (*a*) After the blocks have been impregnated and weighed to obtain absorption, and if they are not to be put through a weathering test, they shall be spaced on trays or racks and left to dry under open laboratory room conditions for 24 hr. Place all such treated blocks, whether conditioned or oven-dried initially, in the conditioning room and leave there for 21 days.

(*b*) Weigh the individual blocks to the nearest 0.01 g just before they are to be placed in contact with the test fungus (Section 12). This weight (T_3) (Note 8) will be used in determining the percentage loss during the decay test (Section 15).

NOTE 8.—Coding the different weights as T_1, T_2, and T_3, as in the preceding Paragraph (*b*) and in Sections 9(*a*) Item (*1*) and 9(*d*) avoids confusion and simplifies recording. The suggested system of T (tare) designations is as follows, with all weights to be recorded in grams:

T_1 = initial weight of the conditioned or oven-dried test block before impregnation,
T_2 = weight of the test block immediately after impregnation and wiping (equals T_1 plus grams of treating solution absorbed),
T_3 = weight of the test block plus residual preservative after conditioning and before exposure to the test fungus,

T_{3w} = weight of the test block plus residual preservative after weathering and conditioning and before exposure to the test fungus (see Section 11(*d*)),
T_m = weight of the test block immediately after removal from the test bottle and after adhering mycelium has been brushed off (see Section 14), and
T_4 = weight of the test block after test and after final conditioning (see Section 14).

Preservative Permanence; Weathering Procedure

11. (*a*) *General.*—Determine the leachability and volatility of preservatives by exposing the blocks in a weathering box (Fig. 2) at 48.9 ± 1.1 C (120 ± 2 F) for 14 days except for 2-hr periods on each of 9 days when they are to be leached in distilled water at room temperature. Space eight or fewer similarly treated test blocks around the edge of the hardware screen support in the beaker, without touching the side of the beaker or one another. Locate the weathering box in such a way that the air above it is free from drafts. Measure the specified temperature at the center of the hardware screen.

(*b*) *Weathering Schedule.*—A suggested weathering schedule that would eliminate the attention of an investigator during week ends is as follows: Start the schedule on a Monday and keep the blocks at 48.9 C (120 F) for 24 hr until Tuesday. On Tuesday and on each day through Friday of the first week remove the blocks from this drying temperature for only the 2-hr leaching periods. On Saturday and Sunday leave the blocks at 48.9 C (120 F) without any leaching. Resume the 2-hr leaching periods on Monday through Friday of the second week. On Saturday and Sunday of the second week leave the blocks dry at 48.9 C (120 F). Terminate the test on Monday, or 14 days after its start.

(*c*) *Leaching Procedure.*—For the leaching phase, weight down with glass (for example, glass paper weights), the blocks in each beaker, and add distilled water to fill the beaker. The volume of distilled water required is approximately nine times the volume of the blocks. Then remove the beakers from the box and keep them at room temperature for 2 hr. At the end of this time pour off the water from the blocks, remove the weight, and return the beaker containing the blocks to the weathering box.

(*d*) *Weighing.*—At the end of the weathering schedule, place the blocks directly in the conditioning room. As soon as the blocks have reached a constant moisture equilibrium, weigh each block to the nearest 0.01 g (T_{3w}) (see Note 8).

Infection of Test Blocks

12. Before putting the test blocks in the culture bottles, place them by retention groups into tightly-fitting containers and steam at 100 C (212 F) for 20 min at atmospheric pressure. After cooling, place the test blocks, with a cross-section face down on the feeder blocks, in the previously prepared test bottles (see Fig. 3 and Section 8(*a*)).

Incubation and Duration of Test

13. Place the bottles containing the test blocks in the incubation room and keep there for 12 weeks.

Handling Test Blocks after Exposure to Test Fungi

14. At the end of the incubation period (Section 13), remove the blocks from the culture bottles. Carefully brush off the mycelium. If data on moisture content in the blocks are desired, weigh the blocks (T_m) (see Note 8). Then place the blocks on trays or racks and

first allow to dry under relative humidity conditions of less than 50 per cent (in an environment where the relative humidity is at least 20 per cent below the relative humidity of the conditioning room, and where the blocks will dry to a moisture content at least 2 per cent below the approximate 12 per cent moisture they will reach in the conditioning room). No heat in excess of 32.2 C (90 F) shall be used. Then bring the blocks to moisture equilibrium in the conditioning room, after which weigh individually to the nearest 0.01 g (T_4).

Calculation of Weight Losses

15. Calculate the percentage weight loss from the conditioned weights of the block, immediately before and after testing, as follows (Note 8):

$$\text{Weight loss, per cent} = \frac{100(T_3 - T_4)}{T_3}$$

Use T_{3w} instead of T_3 in the case of weathered blocks.

Table I in the Appendix is an example of data recording and calculations.

Evaluation of Test Results

16. *Threshold Retention.*—The purpose of the test is to determine the minimum amount of preservative that is effective in preventing decay, under the conditions of the test, by a particular fungus. This amount of preservative, in terms of pounds per cubic foot of wood, is referred to as the threshold retention. The threshold is determined by visual inspection and by estimating the point at which percentage weight losses caused by decay do not occur.

(*a*) *Visual Evidence of Decay.*—Examine the blocks after they have been conditioned and weighed at the completion of the test. Distortion, shrinkage, and softening of the blocks shall be considered as evidences of decay. The abnormalities are usually pronounced in the blocks with the lower retentions of preservatives, but they become progressively less evident with higher retentions, until they are no longer apparent. Visual inspection shall not be relied on entirely since decay is sometimes not readily seen, especially near the threshold retention level.

(*b*) *Use of Percentage Weight Losses.*—The percentage weight loss as calculated (Section 15) may contain certain operational complications. These may be the result of loss of preservative during the test period or failure of the blocks to come to exactly the same moisture equilibrium as before the test period. Such losses, which are not due to decay, may show a progressive decrease from higher to lower retentions, particularly in the case of a volatile preservative (Fig. 4). When, however, the weight losses in blocks show an increase, and the increase is progressive in blocks having lower retentions, decay loss, in addition to any operational loss, is considered to be indicated. The threshold value is then considered to be the average retention at which this transition in weight loss is indicated to occur (Fig. 4 and Table II of the Appendix). In the case of some water-borne preservatives, slight surface decay that is not progressive may be shown by blocks having retentions that are considered somewhat above the threshold. In such instances, decay losses leading to determination of thresholds are not considered to occur until there is a definite increase in weight losses over and above those relatively low ones that result from surface decay.

Refining the Threshold

17. If the threshold is indeterminate

because of wide intervals in the retention gradient chosen, or for any other reason, repeat the test using closer gradient intervals at the approximate threshold level, with a view to locating the threshold as accurately as possible under the test conditions.

Report

18. Reports of test results shall include concise information and data on essential phases of the test (Note 9).

NOTE 9.—The following is an example of the information that should be included in the report:

(*1*) *Species of Wood.*—Southern pine sapwood, 5 to 8 rings per inch.

(*2*) *Test Fungi.*—*Lentinus lepideus* (Madison 534).

(*3*) *Character of Soil.*—Silt loam, water-holding capacity, pH, and weight per 100 ml sifted air dry.

(*4*) *Test Procedures.*—According to standards as outlined. Any deviations from standard procedures to be fully described.

(*5*) *Preservatives.*—Name and chemical description of preservative sufficient to identify it fully, tested concentrations, type of carrier (if petroleum oil, include such characteristics as specific gravity, viscosity, distillation (Method of Test for Distillation of Gas Oil and Similar Distillate Fuel Oils (ASTM Designation: D 158)),[4] per cent aromatics, and per cent unsaturates).

(*6*) *Average retention gradients* of preservatives at treatment (pounds per cubic foot), based on preservative or preservative plus carrier.

(*7*) *Threshold values* in pounds per cubic foot (or kilograms per cubic meter) of preservative for each fungus. The following threshold values (for example) shall be reported for:

	Threshold Values, lb per cu ft
CONDITIONED BLOCKS	
Retention at treatment	5.0
Residual preservative	4.0
WEATHERED BLOCKS	
Retention at treatment	6.5
Residual preservative	4.5

(*8*) *Report Form.*—For an example of recording and calculating the necessary data, see Table I in the Appendix. An example of the threshold determination is shown in Fig. 4 and Table II of the Appendix.

(See Appendix, p. 294)

APPENDIX

TABLE I.—EXAMPLE OF DATA RECORDING AND CALCULATIONS.

Block No.	Fungus No.	T_1 or X_1, grams	T_2, grams	G, grams	C, per cent	$\frac{CG}{100}$, grams	R, lb per cu ft	T_3 or X_3, grams	$T_3 - T_1$, grams	R_c,* lb per cu ft	T_{3w} or X_{3w}, grams	$T_{3w} - T_1$, grams	R_w,* lb per cu ft	T_4, grams	Weight Loss, per cent
131A	534	4.36	7.44	3.08	10.6	0.326	2.95	4.58	0.22	1.99	...	...	...	4.25	7.2
109A	698	4.16	7.41	3.25	10.6	0.344	3.11	4.40	0.24	2.17	...	...	...	4.30	2.3
112A	534	4.15	7.44	3.29	10.6	0.349	3.15	...	...	...	4.32	0.13	1.17	3.38	21.8
130A	698	4.62	7.48	2.87	10.6	0.304	2.75	...	...	...	4.76	0.10	0.90	4.53	4.8
CONTROLS FOR CORRECTING $T_3 - T_1$, IF NECESSARY (SEE NOTE 7)															
Avg. of 5 blocks	...	4.41						4.41							
CONTROLS FOR CORRECTING $T_{3w} - T_1$, IF NECESSARY (SEE NOTE 7)															
Avg. of 5 blocks	534	4.63									4.67				
Avg. of 5 blocks	698	4.35									4.39				
Mean avg.	...	4.49									4.53				

* Calculations of residual amounts of material in the test blocks following conditioning (R_c) or weathering and reconditioning (R_w) are feasible only with materials whose retentions and residual amounts are great enough to be reliably weighed. Accurate determinations of residual amounts of specific chemicals will generally require chemical assays.

Weights:

T_1 = weight of the test block, after reaching moisture equilibrium in conditioning room, before treatment.

T_2 = weight of the test block immediately after impregnation (T_1 plus grams of treating solutions absorbed).

T_3 = weight of the test block plus residual material just before testing and after conditioning.

T_{3w} = weight of the block plus residual material just before testing and after weathering and reconditioning.

T_4 = weight of the block after test and reconditioning.

X_1 = average weight of all untreated control blocks used for adjusting $T_3 - T_1$ or $T_{3w} - T_1$, at the time the T_1 weights are obtained.

X_3 = average weight of all the untreated blocks used for adjusting $T_3 - T_1$, at the time the T_3 weights are obtained.

X_{3w} = average weight of all the untreated blocks used for adjusting $T_{3w} - T_1$, at the time the T_{3w} weights are obtained.

Calculations:

G = grams of treating solution absorbed by the block ($T_2 - T_1$).

C = grams of material in 100 g of treating solution.

$\frac{CG}{100}$ = grams of material absorbed by the block during impregnation.

$T_3 - T_1$ = grams of residual material in the block after conditioning, but before testing.

NOTE.—Use $T_3 - \frac{T_1 X_3}{X_1}$ if it gives a significantly different result. In this example, it did not because X_3 equals X_1. It would always be necessary when T_1 is an oven-dry weight.

$T_{3w} - T_1$ = grams of residual material in the block, after conditioning, weathering, and reconditioning, but before testing.

NOTE.—Use $T_{3w} - \frac{T_1 X_{3w}}{X_1}$ if it gives a significantly different result, as in this example, where the correction reduces R_w as much as 25 per cent. It would always be necessary when T_1 is an oven-dry weight.

R = pounds of material per cubic foot of wood in the block at treatment.

R_c = pounds of residual material per cubic foot after conditioning, but before testing.

R_w = pounds of residual material per cubic foot after weathering, and reconditioning, but before testing.

Weight loss = percentage loss in weight of block from T_3 or T_{3w} level to T_4 level; that is

$$\frac{100\ (T_3 - T_4)}{T_3} \text{ or } \frac{100\ (T_{3w} - T_4)}{T_{3w}}.$$

TABLE II.—RETENTIONS AND WEIGHT LOSSES AS PLOTTED IN FIG. 4 FOR BLOCKS TREATED WITH 5.2 PER CENT PENTACHLOROPHENOL-PETROLEUM SOLUTION.[a]

Treatment Retention, lb per cu ft		Weight Loss, per cent
Preservative Solution	Pentachlorophenol	
Charge 1		
1.83	0.10	9.8
1.88	0.10	10.0
1.88	0.10	13.9
1.91	0.10	8.5
1.88	0.10	15.4
1.84	0.10	10.7
1.77	0.09	16.3
1.73	0.09	11.0
1.79	0.09	9.7
1.76	0.09	12.8
Charge 2		
2.75	0.14	5.8
2.81	0.15	3.4
2.83	0.15	4.6
2.79	0.14	3.5
2.64	0.14	4.1
2.72	0.14	5.8
2.76	0.14	5.7
2.68	0.14	4.1
2.89	0.15	2.3
2.81	0.15	5.2
Charge 3		
3.75	0.20	2.9
3.59	0.19	3.7
3.87	0.20	2.8
3.59	0.19	2.9
3.79	0.20	1.7
3.49	0.18	2.8
3.67	0.19	2.3
3.76	0.20	2.2
3.72	0.19	2.2
3.79	0.20	2.2
Charge 4		
4.66	0.24	2.0
4.84	0.25	1.1
4.82	0.25	1.7
4.97	0.26	2.0
4.54	0.24	1.9
4.88	0.25	2.2
4.76	0.25	2.0
4.82	0.25	1.9
4.88	0.25	1.7
4.46	0.23	2.0
Charge 5		
5.49	0.28	2.2
5.65	0.29	2.5
5.49	0.28	2.5
5.65	0.29	2.2
5.71	0.30	1.6
5.64	0.29	2.2
5.49	0.28	1.9
5.77	0.30	1.9
5.55	0.29	2.5
5.46	0.28	2.2
Charge 6		
6.71	0.35	2.4
6.41	0.33	2.4
6.41	0.33	1.6
6.53	0.34	2.4
6.78	0.35	2.6
6.66	0.35	2.4
6.46	0.34	1.9
6.70	0.35	2.2
6.24	0.32	2.6
6.31	0.33	Discarded

[a] Test organism: *Lenzites trabea* (Madison 617).

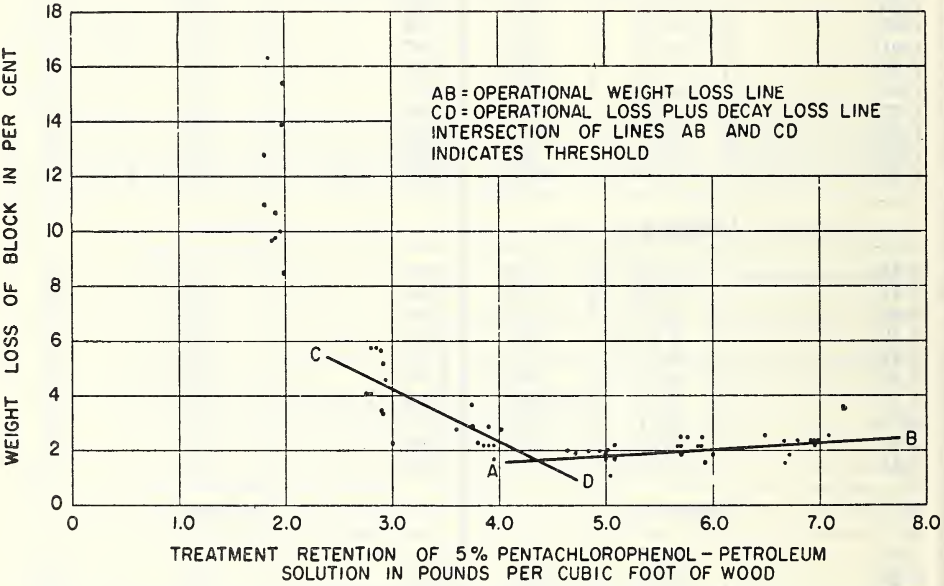

Fig. 4.—Weight Loss for Pentachlorophenol Treated Blocks Put through Soil-Block Test (Test Fungus Madison 617).

Standard Methods of
CHEMICAL ANALYSIS OF ZINC CHLORIDE[1]

ASTM Designation: D 199 - 50

Adopted, 1950.[2]

This Standard of the American Society for Testing Materials is issued under the fixed designation D 199; the final number indicates the year of original adoption as standard or, in the case of revision, the year of last revision.

Reapproved in 1958 Without Change.

Scope

1. (*a*) These methods cover procedures for the chemical analysis of zinc chloride, either in the fused or granulated form or in commercial concentrated solutions, for use in the preservative treatment of wood.

(*b*) The analytical procedures appear in the following order:

	Sections
Insoluble or Basic Zinc Chloride (calculated as zinc oxide)	3 and 4
Zinc (calculated as zinc chloride)	5 and 6
Chlorine (calculated as zinc chloride)	7 and 8
Iron and Aluminum (calculated as iron oxide plus aluminum oxide)	9 and 10

Purity of Reagents and Water

2. (*a*) *Reagents.*—Unless otherwise indicated, it is intended that all reagents shall conform to the specifications of the Committee on Analytical Reagents of the American Chemical Society, where such specifications are available.[3] Other grades may be used, provided it is first ascertained that the reagent is of sufficiently high purity to permit its use without lessening the accuracy of the determination.

(*b*) *Water.*—References to water shall be understood to mean distilled water.

Insoluble or Basic Zinc Chloride

Reagents

3. (*a*) *Standard Hydrochloric Acid (1 N).*—Dilute 85.5 ml. of HCl (sp. gr. 1.18) to 1 liter and standardize. Alternatively, this solution may be prepared by dilution of constant-boiling HCl, in which case standardization will not be required.

(*b*) *Methyl Orange Indicator.*—Dissolve 0.1 g. of methyl orange in water and dilute to 100 ml.

Procedure

4. (*a*) Weigh about 15 g. of the sample,

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[1] Under the standardization procedure of the Society, these methods are under the jurisdiction of the A.S.T.M. Committee D-7 on Wood.

These methods are identical in substance with Sections 1 to 4 of the American Wood Preservers' Association Standard Methods for Analysis of Salt Preservatives (M2-49).

[2] Prior to their present adoption as standard, these methods were published as tentative from 1924 to 1927. They were adopted in 1927 and published as standard from 1927 to 1949. They were reverted to tentative and revised in 1949, and were published as tentative from 1949 to 1950.

[3] "Reagent Chemicals, American Chemical Society Specifications," Am. Chem. Soc., Washington, D. C. For suggestions on the testing of reagents not listed by the American Chemical Society, see "Reagent Chemicals and Standards," by Joseph Rosin, D. Van Nostrand Co., Inc., New York, N. Y., and the "United States Pharmacopoeia."

by difference, from a dry weighing bottle into a 400-ml. beaker. Add about 150 ml. of water, stir to dissolve and transfer to a 1-liter volumetric flask. Wash the beaker, adding the washings to the volumetric flask, dilute to volume, and mix. Filter the entire liter of solution through a medium paper (Note) into a dry 1-liter flask. Toward the end, swirl the volumetric flask so that substantially all of the insoluble matter is collected on the filter. Stopper the flask of filtrate and reserve for the determination of water-soluble zinc (Section 6).

Note.—The commercially available, ready-folded filter papers may be found useful for this purpose.

(*b*) Without washing the residue on the filter, transfer the paper and its contents to a 600-ml. beaker. Immediately rinse the empty volumetric flask with 300 ml. of water and stir until the paper is completely disintegrated. Add 5 to 6 drops of methyl orange indicator and titrate with 1 *N* HCl to a persistent pink end point. Add the acid dropwise and stir vigorously when near the end point.

(*c*) *Calculation.*—Calculate the percentage of water-insoluble matter as ZnO as follows:

$$\text{ZnO, per cent} = \frac{AB \times 0.041}{C} \times 100$$

where:

A = milliliters of HCl required for titration of the sample,

B = normality of the HCl, and

C = grams of sample used.

Zinc[4]

Reagents

5. (*a*) *Sulfuric Acid (sp. gr. 1.84).*

(*b*) *Diphenylamine Indicator.*—Dissolve 1 g. of diphenylamine in 100 ml. of H_2SO_4 (sp. gr. 1.84).

(*c*) *Potassium Ferricyanide Solution (10 g. per l.).*—Dissolve 1 g. of $K_3Fe(CN)_6$ in 100 ml. of water.

(*d*) *Standard Potassium Ferrocyanide Solution (1 ml. = 0.01 g. $ZnCl_2$).*—Dissolve 20.67 g. of $K_4Fe(CN)_6 \cdot 3H_2O$ in water, add 0.2 g. of Na_2CO_3 to stabilize the solution, and dilute to 1 liter in a volumetric flask. If the solution does not contain exactly 20.67 g. of $K_4Fe(CN)_6 \cdot 3H_2O$, standardize it as follows: Weigh between 0.15 and 0.20 g. of pure zinc to the nearest 0.1 mg. Place the zinc in a 500-ml. Erlenmeyer flask and add 10 ml. of HCl (sp. gr. 1.18) to dissolve it. After the initial rapid reaction, rate of solution may be hastened by heating and agitation. When the zinc has completely dissolved, add 50 ml. of water and proceed in accordance with Section 6 (*b*). Calculate the correction factor for the $K_4Fe(CN)_6$ solution as follows:

$$A = \frac{B \times 4.308 \times 1000}{C}$$

$$\text{Correction factor} = \frac{A}{20.67}$$

where:

A = grams of $K_4Fe(CN)_6 \cdot 3H_2O$ per liter of solution,

B = grams of zinc used,

4.308 = grams of $K_4Fe(CN)_6 \cdot 3H_2O$ equivalent to 1 g. of zinc, and

C = milliliters of $K_4Fe(CN)_6$ solution used in the titration.

Procedure

6. (*a*) Transfer a portion of the dry sample or filtered solution containing zinc equivalent to approximately 0.25 g. of $ZnCl_2$ to a 500-ml. Erlenmeyer flask. When the sample is in dry form, use the material as received, but for the determination of water-soluble zinc, use the filtrate from Section 4.

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[4] This procedure is essentially the same as the procedure for zinc in the Standard Methods of Chemical Analysis of Chromated Zinc Chloride (A.S.T.M. Designation: D 1033), see p. 301.

(*b*) Dilute with water to about 50 ml. Add 4 ml. of H_2SO_4 (sp. gr. 1.84), 6 drops of diphenylamine indicator, and 2 or 3 drops of $K_3Fe(CN)_6$ solution. Titrate with $K_4Fe(CN)_6$ solution, while agitating thoroughly. Add the $K_4Fe(CN)_6$ rapidly at first, but as the end point is approached add it dropwise with thorough agitation after each drop. The original blue color of the solution turns to violet as the end point is approached; at the end point it becomes a creamy white or very pale green.

(*c*) *Calculation.*—Calculate the percentage of zinc as $ZnCl_2$, as follows:

$$ZnCl_2\text{, per cent} = \frac{AB}{C}$$

where:

A = milliliters of $K_4Fe(CN)_6$ solution required for titration of the sample,

B = correction factor, if any, determined in accordance with Section 5 (*d*), and

C = grams of sample used.

CHLORINE[5]

Reagents

7. (*a*) *Sodium Bicarbonate*, $NaHCO_3$.

(*b*) *Potassium Chromate Solution.*—Prepare a saturated aqueous solution of K_2CrO_4.

(*c*) *Standard Silver Nitrate Solution* (*1 ml. = 0.01 g. $ZnCl_2$*).—Dissolve 24.93 g. of $AgNO_3$ in water and dilute to 1 liter in a volumetric flask.

Procedure

8. (*a*) Transfer a portion of the dry sample or filtered solution containing chlorine equivalent to approximately 0.20 g. of $ZnCl_2$ to a 300-ml. Erlenmeyer flask. Dilute with water to about 50 ml.

(*b*) Add 2 g. of $NaHCO_3$ and 3 to 5 drops of K_2CrO_4 solution. Titrate with $AgNO_3$ solution to the first appearance of the persistent reddish brown color of Ag_2CrO_4 (Note 1).

NOTE 1.—When the method described in Section 8 is used to determine the strength of treating solutions, the chlorine content of the water used to make up the treating solutions shall be determined in the same manner and appropriate deductions made.

(*c*) *Calculation.*—Calculate the percentage of chlorine as $ZnCl_2$, as follows:

where:

$$ZnCl_2\text{, per cent} = \frac{A}{B}$$

A = milliliters of $AgNO_3$ solution required for titration of the sample, and

B = grams of sample used.

NOTE 2.—Solutions of zinc chloride may undergo a change in composition during use; hence, when samples of such solution are taken from working tanks or treating cylinders, a chlorine analysis may not indicate the exact zinc chloride content.

IRON AND ALUMINUM

Reagents

9. (*a*) *Hydrochloric Acid (1:1).*

(*b*) *Bromine Solution.*—Prepare a saturated aqueous solution of bromine.

(*c*) *Sodium Carbonate Solution (50 g. per l.).*—Dissolve 50 g. of Na_2CO_3 in water and dilute to 1 liter.

(*d*) *Glacial Acetic Acid.*

(*e*) *Sodium Acetate*, $NaC_2H_3O_2$.

(*f*) *Ammonium Hydroxide* (*sp. gr. 0.90*).

Procedure

10. (*a*) Transfer 10 g. of the sample to a 400-ml. beaker. Add 100 ml. of water and sufficient HCl (1:1) just to dissolve all soluble matter. Add bromine solution in slight excess; then boil off excess bromine. Add Na_2CO_3 solution slowly, while stirring, until a slight permanent precipitate of $ZnCO_3$ is obtained. Next add 3 drops of acetic

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[5] This procedure is essentially the same as the procedure for chlorine in A.S.T.M. Methods D 1033, see p. 301.

acid and 2 g. of sodium acetate and boil the solution. Filter and wash the precipitate thus formed.

(*b*) Redissolve the precipitate with HCl (1:1) and wash into the original beaker. Add a slight excess of NH_4OH to reprecipitate the iron and aluminum and bring to a boil. Filter, using an ashless paper, and wash free of chloride.

(*c*) Ignite the paper and precipitate and weigh as Fe_2O_3 plus Al_2O_3.

(*d*) *Calculation.*—Calculate the results as follows:

$$Fe_2O_3 + Al_2O_3\text{, per cent} = \frac{A}{B} \times 100$$

where:

A = grams of ignited residue, and

B = grams of sample used.

Standard Methods of

CHEMICAL ANALYSIS OF CHROMATED ZINC CHLORIDE[1]

ASTM Designation: D 1033 – 50

ADOPTED, 1950.[2]

This Standard of the American Society for Testing Materials is issued under the fixed designation D 1033; the final number indicates the year of original adoption as standard or, in the case of revision, the year of last revision.

Reapproved in 1958 Without Change.

Scope

1. (*a*) These methods cover procedures for the chemical analysis of chromated zinc chloride, either granulated or in commercial concentrated solutions, for use in the preservative treatment of wood.

(*b*) The analytical procedures appear in the following order:

	Sections
Zinc (calculated as zinc chloride)......	3 and 4
Chlorine (calculated as zinc chloride)..	5 and 6
Chromium (calculated as sodium dichromate dihydrate)...............	7 and 8

Purity of Reagents and Water

2. (*a*) *Reagents.*—Unless otherwise indicated, it is intended that all reagents shall conform to the specifications of the Committee on Analytical Reagents of the American Chemical Society, where such specifications are available.[3] Other grades may be used, provided it is first ascertained that the reagent is of sufficiently high purity to permit its use without lessening the accuracy of the determination.

(*b*) *Water.*—References to water shall be understood to mean distilled water.

ZINC[4]

Reagents

3. (*a*) *Sulfuric Acid (1:1).*

(*b*) *Sodium Bisulfite Solution (50 g. per l.).*—Dissolve 5 g. of $NaHSO_3$ in water and dilute to 100 ml.

(*c*) *Ammonium Hydroxide (1:1).*

(*d*) *Ammonium Sulfate,* $(NH_4)_2SO_4$.

(*e*) *Diphenylamine Indicator.*—Dissolve 1 g. of diphenylamine in 100 ml. of H_2SO_4 (sp. gr. 1.84).

(*f*) *Potassium Ferricyanide Solution (10 g. per l.).*—Dissolve 1 g. of $K_3Fe(CN)_6$ in 100 ml. of water.

(*g*) *Standard Potassium Ferrocyanide Solution (1 ml. = 0.01 g. $ZnCl_2$).*—

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[1] Under the standardization procedure of the Society, these methods are under the jurisdiction of the A.S.T.M. Committee D-7 on Wood.

These methods are identical in substance with Sections 3, 6, and 7 of the American Wood Preservers' Association Standard Methods for Analysis of Salt Preservatives (M2-49).

[2] Prior to adoption as standard, these methods were published as tentative from 1949 to 1950.

[3] "Reagent Chemicals, American Chemical Society Specifications," Am. Chem. Soc., Washington, D. C. For suggestions on the testing of reagents not listed by the American Chemical Society, see "Reagent Chemicals and Standards," by Joseph Rosin, D. Van Nostrand Co., Inc., New York, N. Y., and the "United States Pharmacopoeia."

[4] This procedure is essentially the same as the procedure for zinc in the Standard Methods of Chemical Analysis of Zinc Chloride (A.S.T.M. Designation: D 199), see p. 297.

Dissolve 20.67 g. of $K_4Fe(CN)_6 \cdot 3H_2O$ in water, add 0.2 g. of Na_2CO_3 to stabilize the solution, and dilute to 1 liter in a volumetric flask. If the solution does not contain exactly 20.67 g. of $K_4Fe(CN)_6 \cdot 3H_2O$, standardize it as follows: Weigh between 0.15 and 0.20 g. of pure zinc to the nearest 0.1 mg. Place the zinc in a 500-ml. Erlenmeyer flask and add 10 ml. of HCl (sp. gr. 1.18) to dissolve it. After the initial rapid reaction, rate of solution may be hastened by heating and agitation. When the zinc has completely dissolved, proceed in accordance with Section 4 (*c*). Calculate the correction factor for the $K_4Fe(CN)_6$ solution as follows:

$$A = \frac{B \times 4.308 \times 1000}{C}$$

$$\text{Correction factor} = \frac{A}{20.67}$$

where:

A = grams of $K_4Fe(CN)_6 \cdot 3H_2O$ per liter of solution,

B = grams of zinc used,

4.308 = grams of $K_4Fe(CN)_6 \cdot 3H_2O$ equivalent to 1 g. of zinc, and

C = milliliters of $K_4Fe(CN)_6$ solution used in the titration.

Procedure

4. (*a*) Transfer a portion of the dry sample or filtered solution containing zinc equivalent to approximately 0.25 g. of $ZnCl_2$ to a 500-ml. Erlenmeyer flask and dilute with water to about 50 ml.

(*b*) Add 8 ml. of H_2SO_4 (1:1) to the solution and mix well. While gently agitating, add $NaHSO_3$ solution dropwise from a pipet until the solution of the sample changes from its original orange color to green. Add approximately 10 drops of $NaHSO_3$ solution in excess after the final color change. Boil the solution down to a volume of 20 to 25 ml. to expel all SO_2.

(*c*) Cool to about room temperature, add 50 ml. of water, and neutralize to litmus paper with NH_4OH (1:1). Add 25 ml. of H_2SO_4 (1:1) and dilute with water to 150 ml. Add approximately 10 g. of $(NH_4)_2SO_4$ and stir until dissolved. Add 6 drops of diphenylamine indicator and 3 drops of $K_3Fe(CN)_6$ solution. Titrate with the $K_4Fe(CN)_6$ solution. Add the $K_4Fe(CN)_6$ solution rapidly at first, but as the end point is approached add it dropwise with thorough agitation after each drop. Near the end point add 2 more drops of $K_3Fe(CN)_6$ solution. The original blue color of the solution turns to violet as the end point is approached; at the end point it becomes creamy white or very pale green.

(*d*) *Calculation.*—Calculate the percentage of zinc as $ZnCl_2$, as follows:

$$ZnCl_2\text{, per cent} = \frac{AB}{C}$$

where:

A = milliliters of $K_4Fe(CN)_6$ solution required for titration of the sample,

B = correction factor, if any, determined in accordance with Section 3 (*g*), and

C = grams of sample used.

CHLORINE[5]

Reagents

5. (*a*) *Sodium Bicarbonate*, $NaHCO_3$.

(*b*) *Potassium Chromate Solution.*—Prepare a saturated aqueous solution of K_2CrO_4.

(*c*) *Standard Silver Nitrate Solution (1 ml. = 0.01 g. $ZnCl_2$).*—Dissolve 24.93 g. of $AgNO_3$ in water and dilute to 1 liter in a volumetric flask.

Procedure

6. (*a*) Transfer a portion of the dry sample or filtered solution containing chlorine equivalent to approximately

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[5] This procedure is essentially the same as the procedure for chlorine in A.S.T.M. Methods D 199, see p. 297.

0.20 g. of $ZnCl_2$ to a 300-ml. Erlenmeyer flask and dilute with water to about 50 ml.

(*b*) Add 2 g. of $NaHCO_3$ and 3 to 5 drops of K_2CrO_4 solution. Titrate with $AgNO_3$ solution to the first appearance of the persistent reddish brown color of Ag_2CrO_4. (Note 1.)

NOTE 1.—When the method described in Section 4 is used to determine the strength of treating solutions, the chlorine content of the water used to prepare the treating solutions shall be determined in the same manner and appropriate corrections made.

(*c*) *Calculation.*—Calculate the percentage of chlorine as $ZnCl_2$, as follows (Note 2):

$$ZnCl_2\text{, per cent} = \frac{A}{B}$$

where:

A = milliliters of $AgNO_3$ solution required for titration of the sample, and

B = grams of sample used.

To convert the results to chromated zinc chloride, divide the percentage of $ZnCl_2$ by 0.815. This factor applies only to unused solutions.

NOTE 2.—Solutions of chromated zinc chloride may undergo a change in composition during use; hence, when samples of such solutions are taken from working tanks or treating cylinders, a chlorine analysis may not indicate the exact zinc chloride content.

CHROMIUM[6]

Reagents

7. (*a*) *Phosphoric Acid (85 per cent).*

(*b*) *Sulfuric Acid (1:1).*

(*c*) *Ferrous Ammonium Sulfate Solution (140 g. per l.).*—Dissolve 140 g. of $Fe(NH_4)_2(SO_4)_2 \cdot 6H_2O$ in 900 ml. of water and 25 ml. of H_2SO_4 (sp. gr. 1.84). Dilute to 1 liter.

(*d*) *Barium Diphenylamine Sulfonate Indicator.*—Dissolve 0.20 g. of barium diphenylamine sulfonate in water and dilute to 100 ml.

(*e*) *Standard Potassium Dichromate Solution (0.201 N).*—Dissolve 9.872 g. of $K_2Cr_2O_7$ in water and dilute to 1 liter in a volumetric flask. One milliliter of 0.201 N $K_2Cr_2O_7$ solution is equivalent to 0.01 g. of $Na_2Cr_2O_7 \cdot 2H_2O$.

Procedure

8. (*a*) Transfer a portion of the dry sample or filtered solution containing chromium equivalent to about 0.25 g. of $Na_2Cr_2O_7 \cdot 2H_2O$ to a 500-ml. Erlenmeyer flask and dilute with water to about 200 ml.

(*b*) Add 3 ml. of H_3PO_4 and 6 ml. of H_2SO_4 (1:1) and stir the solution well. Pipet 25.0 ml. of ferrous ammonium sulfate solution into the solution of the sample and add 10 drops of barium diphenylamine sulfonate solution. Titrate with $K_2Cr_2O_7$ solution to a deep purple or deep green end point.

(*c*) *Blank.*—Pipet 25.0 ml. of the same ferrous ammonium sulfate solution used in Paragraph (*b*) into another 500-ml. Erlenmeyer flask. Dilute to about 200 ml., add 3 ml. of H_3PO_4 and 10 drops of barium diphenylamine sulfonate indicator, and titrate with $K_2Cr_2O_7$ solution. Ferrous ammonium sulfate solutions change strength quite rapidly. This blank determination should therefore be repeated at frequent intervals.

(*d*) *Calculation.*—Calculate the percentage of chromium as $Na_2Cr_2O_7 \cdot 2H_2O$, as follows:

$$Na_2Cr_2O_7 \cdot 2H_2O\text{, per cent} = \frac{A - B}{C}$$

where:

A = milliliters of $K_2Cr_2O_7$ solution required for titration of the blank,

B = milliliters of $K_2Cr_2O_7$ required for titration of the sample, and

C = grams of sample used.

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[6] This procedure is essentially the same as the procedure for chromium in the Standard Methods of Chemical Analysis of Tanalith (A.S.T.M. Designation: D 1035), see p. 314.

Standard Methods for

CHEMICAL ANALYSIS OF COPPERIZED CHROMATED ZINC CHLORIDE[1]

ASTM Designation: D 1273 – 56

Adopted, 1956.[2]

This Standard of the American Society for Testing Materials is issued under the fixed designation D 1273; the final number indicates the year of original adoption as standard or, in the case of revision, the year of last revision.

Scope

1. (*a*) These methods cover procedures for the chemical analysis of copperized chromated zinc chloride, granulated, in commercial concentrated solutions, or working solutions, for use in the preservative treatment of wood.

(*b*) The analytical procedures appear in the following order:

	Sections
Zinc (calculated as zinc chloride).....	3 and 4
Copper (calculated as copper chloride dihydrate)......................	5 and 6
Hexavalent chromium (calculated as sodium dichromate dihydrate).....	7 and 8
Chloride.........................	9 and 10

Purity of Reagents and Water

2. (*a*) *Reagents.*—Unless otherwise indicated, it is intended that all reagents shall comform to the specifications of the Committee on Analytical Reagents of the American Chemical Society, where such specifications are available.[3] Other grades may be used, provided it is first ascertained that the reagent is of sufficiently high purity to permit its use without lessening the accuracy of the determination.

(*b*) *Water.*—References to water shall be understood to mean distilled water.

Zinc

Reagents

3. (*a*) *Sulfuric Acid (1:1).*

(*b*) *Sulfuric Acid (1:20).*

(*c*) *Ammonium Hydroxide (1:1).*

(*d*) *Ammonium Sulfate,* $(NH_4)_2SO_4$.

(*e*) *Diphenylamine Indicator.*—Dissolve 1 g of diphenylamine in 100 ml of H_2SO_4 (sp gr 1.84).

(*f*) *Potassium Ferricyanide Solution (10 g per l).*—Dissolve 1 g of $K_3Fe(CN)_6$ in 100 ml of water.

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[1] Under the standardization procedure of the Society, these methods are under the jurisdiction of the ASTM Committee D-7 on Wood.

These methods are identical in substance with appropriate sections of the American Wood Preservers' Association Standard Methods for Analysis of Salt Preservatives (A2-51).

[2] Prior to adoption as standard, these methods were published as tentative from 1953 to 1956.

[3] "Reagent Chemicals, American Chemical Society Specifications," Am. Chem. Soc., Washington, D. C. For suggestions on the testing of reagents not listed by the American Chemical Society, see "Reagent Chemicals and Standards," by Joseph Rosin, D. Van Nostrand Co., Inc., New York, N. Y., and the "United States Pharmacopoeia."

(*g*) *Hydrogen Sulfide.*

(*h*) *Standard Potassium Ferrocyanide Solution.*—Dissolve 20.67 g of $K_4Fe(CN)_6 \cdot 3H_2O$ in water, add 0.2 g of Na_2CO_3 to stabilize the solution, and dilute to 1 liter in a volumetric flask. If the solution does not contain exactly 20.67 g of $K_4Fe(CN)_6 \cdot 3H_2O$, standardize it as follows: Weigh between 0.15 and 0.20 g of pure zinc to the nearest 0.1 mg. Place the zinc in a 500-ml Erlenmeyer flask and add 10 ml HCl (sp gr 1.18) to dissolve it. After the initial rapid reaction, rate of solution may be hastened by heating and agitation. When the zinc has completely dissolved, proceed in accordance with Section 4(*c*). Calculate the normality of the $K_4Fe(CN)_6$ solution as follows:

$$\text{Normality} = \frac{A}{0.03269B}$$

where:

A = grams of zinc weighed,
B = milliliters of $K_4Fe(CN)_6$ used in the titration.

Procedure

4. (*a*) Transfer a portion of the dry sample or filtered solution (Note) containing zinc equivalent to approximately 0.25 g of $ZnCl_2$, to a 400-ml beaker, and dilute with water to about 150 ml.

NOTE.—Samples of solutions from working tanks or other treating-plant equipment should be filtered at working temperature immediately on obtaining, and should not be filtered at the time the analysis is performed. Should any precipitate or solid adhering to the container be present when the sample is analyzed, the solution should be thoroughly mixed before analysis, in order to obtain a proper sample.

(*b*) Add 8 ml of H_2SO_4 (1:1) to the solution and mix well. Bubble H_2S gas through the solution at a medium rate for about 20 min. Filter into a 600-ml beaker, using a medium paper. Wash several times with H_2SO_4 (1:20) and reject the precipitate. Boil the solution down to a volume of 50 ml to expel all H_2S.

(*c*) Cool to about room temperature, and transfer to a 500-ml Erlenmeyer flask. Neutralize to litmus paper with NH_4OH (1:1) and add 25 ml H_2SO_4 (1:1). Dilute to 150 ml, add approximately 10 g of $(NH_4)_2SO_4$, and dissolve. Cool to room temperature. Add 6 drops of diphenylamine indicator and 3 drops of $K_3Fe(CN)_6$ solution. Titrate with the $K_4Fe(CN)_6$ solution rapidly at first, but as the end point is approached, add it dropwise, with thorough agitation after each drop. Near the end point, add 2 more drops of $K_3Fe(CN)_6$ solution. The original blue color of the solution turns to violet as the end point is approached; at the end point it becomes creamy white or very pale green.

(*d*) *Calculation.*—Calculate the percentage of zinc as $ZnCl_2$ as follows:

$$ZnCl_2\text{, per cent} = \frac{AB \times 6.814}{C}$$

where:

A = milliliters standard $K_4Fe(CN)_6$ solution required for titration of the sample,
B = normality of $K_4Fe(CN)_6$ as determined by standardization, and
C = grams of sample used.

COPPER

Reagents

5. (*a*) *Hydrochloric Acid.*

(*b*) *Ethyl Alcohol (95 per cent).*—Methyl alcohol or industrial alcohol SD-1 may also be employed.

(*c*) *Sodium Hydroxide Solution.*—Dissolve 20 g NaOH in water, and dilute to 100 ml.

(*d*) *Potassium Iodide Solution.*—Dissolve 20 g KI in water and dilute to 100 ml.

(*e*) *Starch Indicator.*—Dissolve 0.5 g starch in water, and dilute to 100.0 ml.

(*f*) *Sodium Thiosulfate Solution (0.01 N).*—Dissolve 2.482 g of $Na_2S_2O_3 \cdot 5H_2O$ in water, and dilute to 1 liter.

Procedure

6. (*a*) Transfer a portion of the dry sample or filtered solution (see Note, Section 4(*a*)) containing copper equivalent to approximately 0.10 g of $CuCl_2 \cdot 2H_2O$ to a 300-ml Erlenmeyer flask, and dilute with 10 ml of water.

(*b*) Add 5 ml of HCl and 5 ml of 95 per cent ethyl alcohol. Stir, and boil till all chromium is reduced, as evidenced by the disappearance of any yellow-green or brownish color. The reduced solution should be a clear green at this point.

(*c*) Wash down sides of flask with water, boil for 1 min, and neutralize with NaOH solution by adding slowly and stirring constantly until a permanent precipitate just forms.

(*d*) Add HCl until the precipitate just dissolves, cool, add 10 ml of KI solution, and stir well.

(*e*) Titrate with $Na_2S_2O_3$ solution, adding 5 ml starch solution shortly before the end point is reached, and continuing titration until the color of the solution changes from blue to light green.

(*f*) *Calculation.*—Calculate the percentage of copper as $CuCl_2 \cdot 2H_2O$, as follows:

$$CuCl_2 \cdot 2H_2O\text{, per cent} = \frac{A \times 0.1703}{B}$$

where:

A = milliters of $Na_2S_2O_3$ solution required for titration of sample, and

B = grams of sample used.

HEXAVALENT CHROMIUM[4]

Reagents

7. (*a*) *Phosphoric Acid (85 per cent).*

(*b*) *Sulfuric Acid (1:1).*

(*c*) *Ferrous Ammonium Sulfate Solution (140 g. per l).*—Dissolve 140 g of $Fe(NH_4)_2(SO_4)_2 \cdot 6H_2O$ in 900 ml of water and 25 ml of H_2SO_4 (sp gr 1.84). Dilute to 1 liter.

(*d*) *Barium Diphenylamine Sulfonate Indicator.*—Dissolve 0.20 g of barium diphenylamine sulfonate in water and dilute to 100 ml.

(*e*) *Standard Potassium Dichromate Solution (0.201 N).*—Dissolve 9.872 g of $K_2Cr_2O_7$ in water and dilute to 1 liter in a volumetric flask. One milliliter of 0.201 *N* $K_2Cr_2O_7$ solution is equivalent to 0.01 g of $Na_2Cr_2O_7 \cdot 2H_2O$.

Procedure

NOTE.—This analysis should be performed as soon as possible after the sample is obtained.

8. (*a*) Transfer a portion of the dry sample or filtered solution (see Note, Section 4(*a*)) containing chromium equivalent to about 0.25 g of $Na_2Cr_2O_7 \cdot 2H_2O$ to a 500-ml Erlenmeyer flask, and dilute with water to about 200 ml.

(*b*) Add 3 ml of H_3PO_4 and 6 ml of H_2SO_4 (1:1), and stir the solution well. Pipet 25.0 ml of ferrous ammonium sulfate solution into the solution of the sample, and add 10 drops of barium diphenylamine sulfonate solution. Immediately titrate with $K_2Cr_2O_7$ solution to a deep green end point.

(*c*) *Blank.*—Pipet 25.0 ml of the same ferrous ammonium sulfate solution used in Paragraph (*b*) into another 500-ml Erlenmeyer flask. Dilute to about 200 ml, add 3 ml of H_3PO_4 and 10 drops of barium diphenylamine sulfonate indicator, and titrate with $K_2Cr_2O_7$ solution. Ferrous ammonium sulfate solutions change strength quite rapidly, this blank determination should be repeated at frequent intervals.

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[4] This procedure is essentially the same as the procedure for chromium in the Methods of Chemical Analysis of Tanalith (ASTM Designation: D 1035), see p. 314.

(*d*) *Calculation.*—Calculate the percentage of hexavalent chromium as $Na_2Cr_2O_7 \cdot 2H_2O$, as follows:

$$Na_2Cr_2O_7 \cdot 2H_2O\text{, per cent} = \frac{A - B}{C}$$

where:

A = milliliters of $K_2Cr_2O_7$ solution required for titration of the blank,
B = milliliters of $K_2Cr_2O_7$ required for titration of the sample, and
C = grams of sample used.

CHLORIDE

Reagents

9. (*a*) *Sodium Bicarbonate*, $NaHCO_3$.

(*b*) *Potassium Chromate Solution.*—Prepare a saturated aqueous solution of K_2CrO_4.

(*c*) *Standard Silver Nitrate Solution* (*1 ml = 0.005 g Cl*).—Dissolve 23.96 g of $AgNO_3$ in water, and dilute to 1 liter in a volumetric flask.

Procedure

10. (*a*) Transfer a portion of the filtered solution (See Note, Section 4(*a*)) containing approximately 0.10 g of Cl^- to a 300-ml Erlenmeyer flask, and dilute with water to about 50 ml.

(*b*) Add 2 g of $NaHCO_3$ and 3 to 5 drops of K_2CrO_4 solution. Titrate with $AgNO_3$ solution to the first appearance of the persistent reddish brown color of Ag_2CrO_4 (Note 1).

NOTE 1.—When the method described in Paragraphs (*a*) and (*b*) is used to determine the strength of treating solutions, the chloride content of the water used to prepare the treating solutions shall be determined in the same manner, and appropriate corrections made.

(*c*) *Calculation.*—Calculate the percentage of chloride as follows (Note 2):

$$Cl^-\text{, per cent} = \frac{0.5A}{B}$$

where:

A = milliliters of $AgNO_3$ solution required for titration of the sample, and
B = grams of sample used.

To convert the results to copperized chromated zinc chloride, multiply the percentage of Cl^- by 2.446 (or divide by 0.409). This factor applies only to unused solutions.

NOTE 2.—Solutions of copperized chromated zinc chloride may undergo a change in composition during use; hence, when samples of such solutions are taken from working tanks or treating cylinders, a chloride analysis may not indicate the exact (actual) preservative content.

Standard Methods for

CHEMICAL ANALYSIS OF AMMONIACAL COPPER ARSENITE[1]

ASTM Designation: D 1326 – 56

Adopted, 1956.[2]

This Standard of the American Society for Testing Materials is issued under the fixed designation D 1326; the final number indicates the year of original adoption as standard or, in the case of revision, the year of last revision.

Scope

1. (*a*) These methods cover procedures for the chemical analysis of commercial solutions of ammoniacal copper arsenite

(*b*) The analytical procedures appear. in the following order:

	Sections
Ammonia (calculated as anhydrous ammonia)	3 to 5
Arsenic (calculated as arsenic trioxide)	6 to 7
Copper (calculated as cupric hydroxide)	8 to 9

Purity of Reagents

2. (*a*) Reagent grade chemicals shall be used in all tests. Unless otherwise indicated, it is intended that all reagents shall conform to the specifications of the Committee on Analytical Reagents of the American Chemical Society, where such specifications are available.[3] Other grades may be used, provided it is first ascertained that the reagent is of sufficiently high purity to permit its use without lessening the accuracy of the determination.

(*b*) Unless otherwise indicated, references to water shall be understood to mean distilled water.

Ammonia

Apparatus

3. A suitable apparatus for the distillation of ammonia is shown in Fig. 1.

Reagents

4. (*a*) *Sodium Hydroxide Solution (100 g NaOH per liter).*—Dissolve 100 g of NaOH in water and dilute to 1 liter.

(*b*) *Phenolphthalein Indicator Solution.*—Dissolve 1 g of phenolphthalein in 100 ml of alcohol.

(*c*) *Standard Sodium Hydroxide Solution (0.1 N).*—Dissolve 4 g of NaOH in CO_2-free water and dilute to 1 liter with CO_2-free water.

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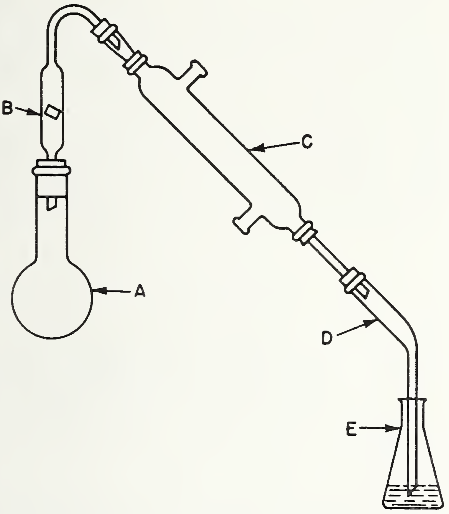
[1] Under the standardization procedure of the Society, these methods are under the jurisdiction of the ASTM Committee D-7 on Wood.

[2] Prior to adoption as standard, these methods were published as tentative from 1954 to 1956.

[3] "Reagent Chemicals, American Chemical Society Specifications," Am. Chem. Soc., Washington, D. C. For suggestions on the testing of reagents not listed by the American Chemical Society, see "Reagent Chemicals and Standards," by Joseph Rosin, D. Van Nostrand Co., Inc., New York, N. Y., and the "United States Pharmacopoeia."

Standardize as follows: Place two 0.8000-g portions of potassium acid phthalate (National Bureau of Standards standard sample No. 84) in volumetric flasks, and add 100 ml of freshly boiled water and 2 drops of phenolphthalein indicator solution to each flask. Titrate with the NaOH solution to the appearance of a faint, persistent pink color. The titrations should agree within 0.1 ml; record the average. Calculate the normality of the NaOH solution as follows:

$$\text{Normality of NaOH solution} = \frac{3.920}{\text{ml of NaOH}}$$



A—Round-bottom flask, 500-ml.
B—Distillation trap.
C—Condenser.
D—Delivery tube.
E—Erlenmeyer flask, 500-ml.

FIG. 1.—Distillation Apparatus for Determination of Ammonia in Ammoniacal Copper Arsenite.

(*d*) *Standard Sulfuric Acid (0.1 N)*.—To 100 ml of water in a 1000-ml volumetric flask, add 3.3 ml of H_2SO_4 (sp gr 1.84); mix and cool to 20 C. Dilute to the mark with water.

Standardize as follows: Pipet 25 ml of the H_2SO_4 solution into a 500-ml Erlenmeyer flask, and add 100 ml of water and 2 drops of phenolphthalein indicator solution. Titrate with the 0.1 *N* NaOH solution to the appearance of a faint, persistent pink color. Calculate the normality of the H_2SO_4 as follows:

$$\text{Normality of } H_2SO_4 = \frac{\text{normality of NaOH} \times \text{ml of NaOH}}{25}$$

(*e*) *Methyl Purple or Methyl Red Indicator Solution*.—Suitable prepared solutions of methyl purple can be purchased. To prepare the methyl red indicator solution, dissolve 0.1 g of methyl red in 50 ml of alcohol (90 per cent), dilute to 100 ml with water, and filter if necessary.

Procedure

5. (*a*) Transfer a portion of the sample containing not more than 0.15 g of NH_3 (Note) to the 500-ml distillation flask. Dilute with water to a volume of about 200 ml. Add a few glass beads to prevent bumping. Add 20 ml NaOH solution (100 g NaOH per liter) and immediately close the flask with a rubber stopper through which a spray trap has been inserted. The spray trap shall previously have been connected to a vertical condenser. Place 100 ml of 0.1 *N* H_2SO_4 in a 400-ml beaker. Adjust the tip of the condenser so that it just dips into the H_2SO_4. Add 4 to 5 drops of methyl purple or methyl red indicator solution to the H_2SO_4.

NOTE.—If this procedure is used for testing a solution of treating strength, use an accurately measured volume of the filtered solution equivalent to the appropriate amount of the element to be determined.

(*b*) After making sure all the connections are tight, commence heating the mixture of sample and NaOH solution. Distill slowly at first, and finally boil rather vigorously. Distill off about 150 ml of solution. Adjust the height of the beaker throughout the distillation so that the tip of the condenser is always near the surface of the liquid in the receiving vessel. Should the indicator start to turn color, add a measured amount of additional 0.1 *N* H_2SO_4. When distillation is complete, turn out the flame and lower the receiving vessel. Wash down the condenser tube and its tip into the receiver.

(*c*) Titrate the excess acid with 0.1 *N* NaOH solution.

Calculation

6. Calculate the percentage of ammonia as NH_3, as follows:

$$NH_3\text{, per cent} = \frac{(AB - CD) \times 1.703}{E}$$

where:

A = milliliters of H_2SO_4 added to the receiving vessel,
B = normality of the H_2SO_4,
C = milliliters of NaOH solution used for titration of the excess H_2SO_4,
D = normality of the NaOH solution, and
E = grams of sample used.

ARSENIC

Reagents

7. (*a*) *Hydrochloric Acid* (*sp gr 1.18*).

(*b*) *Hypophosphorous Acid* (*50 per cent*).

(*c*) *Sulfuric Acid* (*sp gr 1.84*).

(*d*) *Methyl Orange Indicator Solution.*—Dissolve 0.1 g of methyl orange in water and dilute to 100 ml.

(*e*) *Standard Potassium Bromate Solution* (*0.1000 N*).—Dissolve 2.784 g of $KBrO_3$ in water and dilute to 1 liter in a volumetric flask.

Procedure

8. (*a*) Transfer a portion of the sample containing arsenic equivalent to about 0.15 g As_2O_3 (see note under Section 5(*a*)) to a 250-ml, wide-mouth Erlenmeyer flask and dilute with water to about 50 ml. Add 50 ml of HCl and 20 ml of H_3PO_2, mix thoroughly, and warm the solution on a steam bath until a precipitate forms. Boil gently for about 15 min. With the aid of suction, filter the hot solution through a 10-ml Gooch crucible containing a mat of medium fiber, acid-washed asbestos, washing the flask and precipitate thoroughly with water.

(*b*) Place the crucible containing the precipitate in the flask in which the precipitation was carried out. Discard the filtrate. Pour 10 ml of H_2SO_4 into the flask and while agitating, heat over an open flame in a hood until dense white fumes are evolved. Allow the flask and contents to cool, and then add 100 ml of water very slowly and carefully, especially at first, since heat is generated during this addition. Next, add 5 ml of HCl and two drops of methyl orange indicator and titrate immediately with $KBrO_3$ solution. When the solution becomes colorless, the end point has been reached.

Calculation

9. Calculate the percentage of arsenic as As_2O_3, as follows:

$$As_2O_3\text{, per cent} = \frac{A \times 0.4946}{B}$$

where:

A = milliliters of $KBrO_3$ solution required for titration of the sample, and
B = grams of sample used.

COPPER

Reagents

10. (*a*) *Hydrochloric Acid* (*sp gr 1.84*).

(*b*) *Sodium Hydroxide Solution* (*100 g per l*).—Dissolve 100 g of NaOH in water and dilute to 1 liter.

(*c*) *Potassium Iodide Solution* (*200 g KI per liter*).—Dissolve 200 g of KI in water and dilute to 1 liter.

(*d*) *Standard Sodium Thiosulfate Solution (0.0500 N)*.—Dissolve 12.4103 g of $Na_2S_2O_3 \cdot 5H_2O$ in water and dilute to 1 liter in a volumetric flask.

(*e*) *Starch Indicator Solution*.—Make a paste of 1 g of soluble starch in about 5 ml of water, add 100 ml of water, and boil for 1 min while stirring. Cool and add 1 drop of chloroform. This solution is subject to decomposition and fresh solution should be prepared if a dark-blue color is not produced with a drop of tincture of iodine in 100 ml water on addition of a drop of the starch indicator solution.

(*f*) *Potassium Chlorate - Nitric Acid Mixture*.—Dissolve 5 g of $KClO_3$ in 100 ml of HNO_3 (sp gr 1.42). Prepare this solution just before use and do not save any surplus for use later.

Procedure for New Solutions

11. (*a*) Place the sample in a 300-ml Erlenmeyer flask, and add 10 ml of water and 10 ml of HCl (sp gr 1.19). Wash down the side of the flask with water, boil for 1 min, and neutralize with NaOH solution until a permanent precipitate just forms. Add HCl (sp gr 1.19) dropwise until the precipitate just dissolves. Cool to below 20 C. The solution volume should be 20 to 30 ml.

(*b*) Add 10 ml of KI solution and mix thoroughly by rotating the flask. Titrate with 0.05 *N* $Na_2S_2O_3$ solution, adding 2 ml of starch solution just before the brownish color of the iodine disappears. Stop the titration when the color changes from dark blue to cream color.

(*c*) If poor end points or checks are obtained in the titrations (Paragraph (*b*)), repeat the determination following the procedure described in Section 12.

Procedure for Used Solutions Contaminated with Organic Matter

12. (*a*) In used solutions, the accumulation of organic matter may interfere with the copper analysis, resulting in inconsistent titrations in the determination of copper. In such cases, the organic matter may be destroyed as follows: Place the sample in a 300-ml Erlenmeyer flask, add 10 ml of the $KClO_3$ - HNO_3 mixture, and boil to dryness, with constant agitation. When dry, bake the residue over an open flame for about 1 min. Cool, then add 20 ml water and 10 ml of HCl (sp gr 1.19). Warm, if necessary, to effect complete solution.

(*b*) Cool the solution and proceed in accordance with Section 11, starting with the second sentence of Paragraph (*a*).

Calculation

13. Calculate the percentage of copper as $Cu(OH)_2$, as follows:

$$Cu(OH)_2\text{, per cent} = \frac{A \times 4.880}{B}$$

where:

A = milliliters of standard thiosulfate solution required for titration of the sample, and

B = grams of sample used.

Standard Methods for
CHEMICAL ANALYSIS OF PENTACHLOROPHENOL[1]

ASTM Designation: D 1274 – 56

ADOPTED, 1956.[2]

This Standard of the American Society for Testing Materials is issued under the fixed designation D 1274; the final number indicates the year of original adoption as standard or, in the case of revision, the year of last revision.

Scope

1. (*a*) These methods cover procedures for the chemical analysis of pentachlorophenol for use in the preservative treatment of wood.

(*b*) The analytical procedures appear in the following order:

	Sections
Phenol (calculated as pentachlorophenol)	3 and 4
Alkali-Insoluble Material	5 and 6
Freezing Point	7

Purity of Reagents and Water

2. (*a*) *Reagents.*—Unless otherwise indicated, it is intended that all reagents shall conform to the specifications of the Committee on Analytical Reagents of the American Chemical Society, where such specifications are available.[3] Other grades may be used provided it is first ascertained that the reagent is of sufficiently high purity to permit its use without lessening the accuracy of the determination.

(*b*) *Water.*—References to water shall be understood to mean distilled water.

PHENOL

Reagents

3. (*a*) *Carbon Dioxide-Free Ethyl Alcohol.*

(*b*) *Standard Sodium Hydroxide Solution (0.1 N).*—Prepare a carbonate-free solution of NaOH. The exact normality of this solution shall be determined before use.

(*c*) *Meta-Cresol Purple Indicator.*—Dissolve 0.10 g of meta-cresol purple in 2.62 ml of 0.1 *N* NaOH solution, and dilute to 100 ml with water.

Procedure

4. (*a*) Transfer approximately 1 g of the sample of pentachlorophenol, weighed to the nearest milligram, to a clean 250-ml Erlenmeyer flask, and add 65 ml of ethyl alcohol. Gently swirl the mixture until solution is complete.

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[1] Under the standardization procedure of the Society, these methods are under the jurisdiction of the ASTM Committee D-7 on Wood.

These methods are identical in substance with appropriate sections of the American Wood-Preservers' Association Standard Methods for Analysis of Oil-Borne Preservatives (A5-52).

[2] Prior to adoption as standard, these methods were published as tentative from 1953 to 1956.

[3] "Reagent Chemicals, American Chemical Society Specifications," Am. Chem. Soc., Washington, D. C. For suggestions on the testing of reagents not listed by the American Chemical Society, see "Reagent Chemicals and Standards," by Joseph Rosin, D. Van Nostrand Co., Inc., New York, N. Y., and the "United States Pharmacopoeia."

(*b*) Add 35 ml of water and 0.6 ml of meta-cresol purple indicator. Titrate with 0.1 *N* NaOH solution to the first persistent purple end point. Run a blank on 65 ml of ethyl alcohol and 35 ml of water.

(*c*) *Calculation.*—Calculate the percentage of phenol as pentachlorophenol, as follows:

$$\text{Pentachlorophenol, per cent} = \frac{26.63AB}{C}$$

where:

A = milliliters of NaOH solution required for titration of the sample,
B = normality of the NaOH solution, and
C = grams of sample used.

ALKALI-INSOLUBLE MATERIAL

Reagents

5. *Sodium Hydroxide Solution.*—Dissolve 40 g of NaOH in water, and dilute to 1000 ml with water.

Procedure

6. (*a*) Transfer approximately 1 g of the sample of pentachlorophenol, weighed to the nearest milligram, to a 250-ml beaker, and add 50 ml of NaOH solution and 50 ml of water. Warm to 60 C, and hold at 60 ± 5 C for 15 min.

(*b*) Filter through a tared Gooch crucible having a medium-fiber asbestos mat, wash the residue with water, and dry at 100 C to constant weight.

(*c*) *Calculation.*—Calculate the percentage of alkali-insoluble material as follows:

$$\text{Alkali-insoluble material, per cent} = \frac{A \times 100}{B}$$

where:

A = grams of residue remaining in the Gooch crucible, and
B = grams of sample used.

FREEZING POINT

Procedure

7. (*a*) Fill an enameled cup or a nicke tube of at least 1 in. diameter with sample. Melt in the direct flame of a Bunsen burner in a hood, stirring constantly with a standardized 160 to 195 C thermometer.

(*b*) When the molten mate rial has a temperature about 10 deg above its expected melting point, allowit t o cool while maintaining the constant stirring.

(*c*) *Calculation.*—As the freezing point is reached, heat of crystallization usually causes the temperature to increase slightly. Read the freezing point as the highest point at which the temperature remains constant for at least 15 sec.

Standard Methods of

CHEMICAL ANALYSIS OF TANALITH[1]

ASTM Designation: D 1035 – 50

ADOPTED, 1950.[2]

Reapproved in 1958 Without Change.

This Standard of the American Society for Testing Materials is issued under the fixed designation D 1035; the final number indicates the year of original adoption as standard or, in the case of revision, the year of last revision.

Scope

1. (*a*) These methods cover procedures for the chemical analysis of commercial dry Tanalith.

(*b*) The analytical procedures appear in the following order:

	Sections
Fluorine (calculated as sodium fluoride)	3 to 5
Arsenic (calculated as sodium acid arsenate)	6 and 7
Chromium (calculated as sodium chromate)	8 and 9
Dinitrophenol	10 and 11

Purity of Reagents and Water

2. (*a*) *Reagents.*—Unless otherwise indicated, it is intended that all reagents shall conform to the specifications of the Committee on Analytical Reagents of the American Chemical Society, where such specifications are available.[3] Other grades may be used, provided it is first ascertained that the reagent is of sufficiently high purity to permit its use without lessening the accuracy of the determination.

(*b*) *Water.*—References to water shall be understood to mean distilled water.

FLUORINE

Apparatus

3. A suitable apparatus for the distillation of fluorine is shown in Fig. 1.

Reagents

4. (*a*) *Potassium Permanganate Solution (saturated).*

(*b*) *Sodium Alizarin Sulfonate Indicator.*—Dissolve 0.05 g. of sodium alizarin sulfonate in 100 ml. of water.

(*c*) *Sodium Hydroxide Solution (20 g. per l.).*—Dissolve 2.0 g. of NaOH in 100 ml. of water.

(*d*) *Hydrochloric Acid (1:199).*

(*e*) *Buffer Solution.*—Dissolve 9.448 g. of monochloroacetic acid and 2.000 g. of NaOH in 100 ml. of water.

(*f*) *Standard Thorium Nitrate Solution (0.1 N).*—Dissolve 17.4 g. of $Th(NO_3)_4 \cdot 12H_2O$ in water and dilute to 1 liter. Standardize by titrating the fluorine obtained by distillation of 100 per cent natural cryolite ($3NaF \cdot AlF_3$) or NaF, using the procedure described in Section 5.

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[1] Under the standardization procedure of the Society, these methods are under the jurisdiction of the A.S.T.M. Committee D-7 on Wood.

These methods are identical in substance with Sections 7, 8, 11, and 12 of the American Wood Preservers' Association Standard Methods for Analysis of Salt Preservatives (M2-49).

[2] Prior to their adoption as standard, these methods were published as tentative from 1949 to 1950.

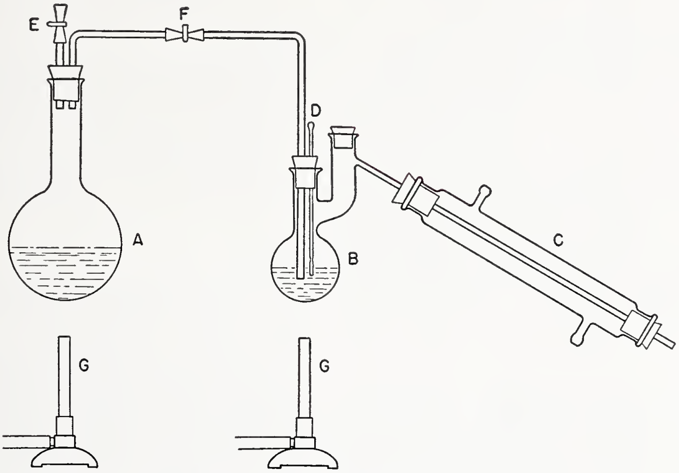
[3] "Reagent Chemicals, American Chemical Society Specifications," Am. Chem. Soc., Washington, D. C. For suggestions on the testing of reagents not listed by the American Chemical Society, see "Reagent Chemicals and Standards," by Joseph Rosin, D. Van Nostrand Co., Inc., New York, N. Y., and the "United States Pharmacopoeia."

Procedure

5. (*a*) Transfer 0.2 g. of the sample, equivalent to about 0.05 g. of NaF (Note), to a 250-ml. Claissen flask, *B*, Fig. 1, containing eight to ten glass beads. Add 5 drops of $KMnO_4$ solution, adjust the total volume to 30 ml. with water, and add 35 ml. of H_2SO_4.

NOTE.—If this procedure is used for testing a Tanalith treating solution, use an accurately measured volume of the filtered solution equivalent to the same amount of the element being determined.

(*b*) Close the flask with a two-hole rubber stopper through which passes a thermometer and a 4-mm. glass tube, both of which extend down into the solution. Use the 4-mm. glass tube to connect the Claissen flask, *B*, Fig. 1, with a 2000-ml. Florence flask, *A*, containing water, which is the source of steam for the ensuing distillation. Connect the Claissen flask, *B*, to the condenser, *C*, and with pinchcock *F* closed, distill until the boiling point reaches 135 C. Meanwhile, bring the water in flask *A* to a boil with pinchcock *E* open. When 135 C. is reached in flask *B*, open pinchcock *F* to admit steam and close pinchcock *E*. Adjust the rate of distillation in flask *B* and the flow of steam from flask *A* so as to maintain a constant volume of liquid in flask *B* and a boiling point of 135 C. Distill until 250 ml. of distillate are collected.



A—Florence flask, 2000-ml. (A number of stills can be operated from a single 2000-ml. Florence flask.)
B—Claissen flask, 250-ml.
C—Liebig condenser.
D—Thermometer.
E and *F*—Pinchcocks.
G—Bunsen burner.

FIG. 1.—Distillation Apparatus for Determination of Sodium Fluoride in Tanalith.

(*c*) To 100 ml. of the distillate, add 8 drops of sodium alizarin sulfonate indicator. Adjust the acidity, using NaOH solution and HCl (1:199), until the solution is just acid and the pink color is discharged. Add 1 ml. of the buffer solution and titrate with $Th(NO_3)_4$ solution to a persistent pink color.

(*d*) *Calculation*.—Calculate the percentage of fluoride as NaF, as follows:

$$\text{NaF, per cent} = \frac{AB \times 0.042}{0.4C} \times 100$$

23-57

where:

A = milliliters of $Th(NO_3)_4$ solution required for titration of the 100-ml. aliquot of the sample,

B = normality of the $Th(NO_3)_4$ solution, and

C = grams of sample used.

ARSENIC

Reagents

6. (*a*) *Hypophosphorous Acid (50 per cent).*

(*b*) *Sulfuric Acid (sp. gr. 1.84).*

(*c*) *Hydrochloric Acid (sp. gr. 1.18).*

(*d*) *Methyl Orange Indicator.*—Dissolve 0.1 g. of methyl orange in water and dilute to 100 ml.

(*e*) *Standard Potassium Bromate Solution (0.1075 N).*—Dissolve 2.993 g. of $KBrO_3$ in distilled water and dilute to 1 liter in a volumetric flask. One milliliter of 0.1075 *N* $KBrO_3$ is equivalent to 0.01 g. of Na_2HAsO_4.

Procedure

7. (*a*) Transfer a portion of the sample containing arsenic equivalent to about 0.25 g. Na_2HAsO_4 (Note, Section 5 (*a*)) to a 250-ml. wide-mouth Erlenmeyer flask and dilute with water to about 50 ml.

(*b*) Add 50 ml. of HCl and 20 ml. of H_3PO_2, mix thoroughly, and warm the solution on a steam bath until a precipitate forms. Boil gently for about 15 min. With the aid of suction, filter the hot solution through a 10-ml. Gooch crucible containing a mat of medium-fiber, acid-washed asbestos, washing the flask and precipitate thoroughly with water.

(*c*) Place the crucible containing the precipitate in the same flask in which the precipitation was carried out. Discard the filtrate. Pour 10 ml. of H_2SO_4 into the flask and heat over an open flame in a hood, while agitating, until dense white fumes are evolved. Allow the flask and contents to cool and then add 100 ml. of water very slowly and carefully, especially at first, as much heat is generated during this addition. Next add 5 ml. of HCl and 2 drops of methyl orange indicator and titrate immediately with $KBrO_3$ solution. When the solution becomes colorless the end point has been reached.

(*d*) *Calculation.*—Calculate the percentage of arsenic as Na_2HAsO_4, as follows:

$$Na_2HAsO_4\text{, per cent} = \frac{A}{B}$$

where:

A = milliliters of $KBrO_3$ solution required for titration of the sample, and

B = grams of sample used.

CHROMIUM[4]

Reagents

8. (*a*) *Phosphoric Acid (85 per cent).*

(*b*) *Sulfuric Acid (1:1).*

(*c*) *Ferrous Ammonium Sulfate Solution (140 g. per l.).*—Dissolve 140 g. of $Fe(NH_4)_2(SO_4)_2 \cdot 6H_2O$ in 900 ml. of water and 25 ml. of H_2SO_4 (sp. gr. 1.84). Dilute to 1 liter.

(*d*) *Barium Diphenylamine Sulfonate Indicator.*—Dissolve 0.20 g. of barium diphenylamine sulfonate in water and dilute to 100 ml.

(*e*) *Standard Potassium Dichromate Solution (0.185 N).*—Dissolve 9.069 g. of $K_2Cr_2O_7$ in distilled water and dilute to 1 liter in a volumetric flask. One milliliter of 0.185 *N* $K_2Cr_2O_7$ solution is equivalent to 0.01 g. of Na_2CrO_4.

Procedure

9. (*a*) Transfer a portion of the sample containing chromium equivalent to about 0.25 g. of Na_2CrO_4 (Note, Section 5(*a*)) to a 500-ml. Erlenmeyer flask and dilute with water to about 200 ml.

(*b*) Add 3 ml. of H_3PO_4 and 6 ml. of

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[4] This procedure is essentially the same as the procedure for chromium in the Standard Methods of Chemical Analysis of Chromated Zinc Chloride (A.S.T.M. Designation: D 1033), see p. 301.

H_2SO_4 (1:1) and stir the solution well. Pipet 25.0 ml. of ferrous ammonium sulfate solution into the solution of the sample and add 10 drops of barium diphenylamine sulfonate indicator. Titrate with $K_2Cr_2O_7$ solution to a deep purple or deep green end point.

(*c*) *Blank.*—Pipet 25.0 ml. of the same ferrous ammonium sulfate solution used in Paragraph (*b*) into another 500-ml. Erlenmeyer flask. Dilute to about 200 ml., add 3 ml. of H_3PO_4 and 10 drops of barium diphenylamine sulfonate indicator, and titrate with $K_2Cr_2O_7$ solution. Ferrous ammonium sulfate solutions change strength quite rapidly. This blank determination should therefor be repeated at frequent intervals.

(*d*) *Calculation.*—Calculate the percentage of chromium as Na_2CrO_4, as follows:

$$Na_2CrO_4\text{, per cent} = \frac{A - B}{C}$$

where:

A = milliliters of $K_2Cr_2O_7$ solution required for titration of the blank,
B = milliliters of $K_2Cr_2O_7$ solution required for titration of the sample, and
C = grams of sample used.

DINITROPHENOL

Reagents

10. (*a*) *Sulfuric Acid* (*sp. gr. 1.84*).
(*b*) *Carbon Tetrachloride*, CCl_4.

Procedure

11. (*a*) Transfer 1.000 g. of the sample, equivalent to about 0.12 g. of dinitrophenol (Note, Section 5(*a*)), to a 150-ml. beaker and dissolve in 50 ml. of water.

(*b*) Transfer the solution to a 250-ml. separatory funnel, add 1 ml. of H_2SO_4, and mix thoroughly. Add 10 ml. of CCl_4 and shake vigorously. Allow the two layers to separate and invert the funnel carefully to free any entrapped liquid. Draw off the lower layer into a weighed 100-ml. beaker, taking care to remove only the clear liquid. Repeat the extraction four times, using 10-ml. portions of CCl_4. When drawing off the last extraction, allow the scum which collects between the two layers to pass into the beaker.

(*c*) Clean the separatory funnel and return the contents of the beaker to it. Wash the beaker first with 5 ml. of CCl_4 and then with 5 ml. of water and add these washings to the liquid in the funnel. Draw off the CCl_4 layer into the beaker that was used previously and extract the remaining water layer twice with 5-ml. portions of CCl_4.

(*d*) Evaporate the CCl_4 solution almost to dryness on a steam bath. Remove the beaker and complete the evaporation at room temperature. Dry for an hour in a desiccator and weigh as dinitrophenol.

(*e*) *Calculation.*—Calculate the percentage of dinitrophenol as follows:

$$\text{Dinitrophenol, per cent} = A \times 100$$

where:

A = grams of residue.

Standard Definitions of
TERMS RELATING TO TIMBER PRESERVATIVES[1]

ASTM Designation: D 324 - 41

ADOPTED. 1933; REVISED, 1941.[2]

Reapproved in 1958 Without Change.

This Standard of the American Society for Testing Materials is issued under the fixed designation D 324; the final number indicates the year of original adoption as standard or, in the case of revision, the year of last revision.

Coal Tar.—Tar produced by the destructive distillation of bituminous coal.

Coke-Oven Tar.—Coal tar produced in by-product coke ovens in the manufacture of coke from bituminous coal.

Creosote (Creosote Oil, Creosote Distillate).—As used in wood preservation, a distillate of coal tar produced by high-temperature carbonization of bituminous coal; it consists principally of liquid and solid aromatic hydrocarbons, and contains appreciable quantities of tar acids and tar bases; it is heavier than water; and has a continuous boiling range of at least 125 C beginning at about 200 C.

Creosote - Coal Tar Solution.—Solution of coal tar in creosote in various proportions. Usually contains 20 to 40 per cent of coal tar.

Creosote Distillate.—See Creosote.

Creosote Oil.—See Creosote.

Gas-House Coal Tar.—Coal tar produced in gas-house retorts in the manufacture of illuminating gas from bituminous coal.

Water-Gas Tar.—Tar produced in the manufacture of carbureted water gas by the decomposition of petroleum oil by heat in the presence of blue gas.

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[1] Under the standardization procedure of the Society, these definitions are under the jurisdiction of the ASTM Committee D-7 on Wood.

[2] Prior to adoption as standard, these definitions were published as tentative from 1930 to 1933, being revised in 1933.

Methods of Testing Building Constructions

Standard Methods of

CONDUCTING STRENGTH TESTS OF PANELS FOR BUILDING CONSTRUCTION[1]

ASTM Designation: E 72 - 55

ADOPTED 1954; REVISED 1955.[2]

This Standard of the American Society for Testing Materials is issued under the fixed designation E 72; the final number indicates the year of original adoption as standard or, in the case of revision, the year of last revision.

Small buildings have never been subjected to a thorough engineering analysis. Structural details for such buildings have for the most part been governed by tradition, precedent, and judgment, supplemented by modifications developed through experience over the years. Many factors now point toward the urgent need of accurate technical data on the strength and rigidity of the basic elements employed in various construction systems. These factors include present trends in the development of new materials and their use singly and in combination with others, the development of new and more efficient systems of construction, the need for performance requirements in codes in lieu of specified construction details, and the desirability of using materials as economically as possible. It is the purpose of these test methods to provide a systematic basis for obtaining comparable engineering data on various construction elements and structural details of value to designers, builders, building officials, and others interested in this field.

To ensure more rapid progress in determining the structural properties of houses, it is desirable to use research methods that have proved to be efficient and economical in the solution of other industrial problems. Subjecting complete houses to known loads is very expensive and requires much time; therefore, that method of carrying out investigations of houses is not likely to be used to any great extent. Such tests have the further disadvantage that only the strength of the weakest elements of a particular house could be measured.

For these reasons it seems more practicable to apply loads to specimens that accurately reproduce a structural portion of a finished house. These portions of a house have been designated as "elements"; for example, floor, wall, roof, etc. For the procedure described in these methods, the elements have been restricted to the most important structural portions of a house. For each element methods of loading are described that simulate the loads to which the element would be subjected under service conditions. It is believed that the results of these measurements on the structural elements of a house will be more useful to architects and engineers than the results of tests on specimens of the materials from which the house was fabricated, or the results of tests of the individual structural members of a house. In all probability, the results will approximate closely those which would be obtained by testing a complete, full-size house.

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[1] Under the standardization procedure of the Society, these methods are under the jurisdiction of the ASTM Committee E-6 on Methods of Testing Building Constructions.

[2] Prior to adoption as standard, these methods were published as tentative from 1947 to 1954, being revised in 1951.

Although it may be impracticable to determine all of the structural properties of each element of a house, it is believed that the more important properties may be determined by tests described in these methods. A graphic method of presenting the results of the tests is also included.

Scope

1. These methods cover the following procedures for determining the structural properties of panels for light building construction:

	Sections
Tests of Walls:	
Axial Loads	6
Compressive Load	7 to 10
Tensile Load	11 to 14
Transverse Load	15 to 21
Concentrated Load	22 to 29
Impact Load	30 to 36
Racking Load	37 to 45
Tests of Partitions, Load-Bearing:	
General Requirements	46
Tests of Partitions, Non-Load-Bearing:	
Impact Load	47 and 48
Concentrated Load	49 and 50
Tests of Floors:	
Transverse Load	51 and 52
Concentrated Load	53 and 54
Impact Load	55 and 56
Tests of Roofs:	
Transverse Load	57 and 58
Concentrated Load	59 and 60

Description of Terms

2. (*a*) *House.*—A small residential structure.

(*b*) *Element.*—A portion of a completed house, such as a floor or wall, having one primary structural function.

(*c*) *Construction.*—The materials, dimensions, and method of fabricating an element of a house. Elements are regarded as of different constructions if there is a significant difference in the materials, dimensions, and methods of fabrication (Note).

NOTE: *Examples.*—Wood construction is a construction having wood structural members. A floor having rolled steel I-beams covered by a reinforced concrete slab is one construction, and a floor having the same I-beams and spacing covered by a wood floor is a different construction.

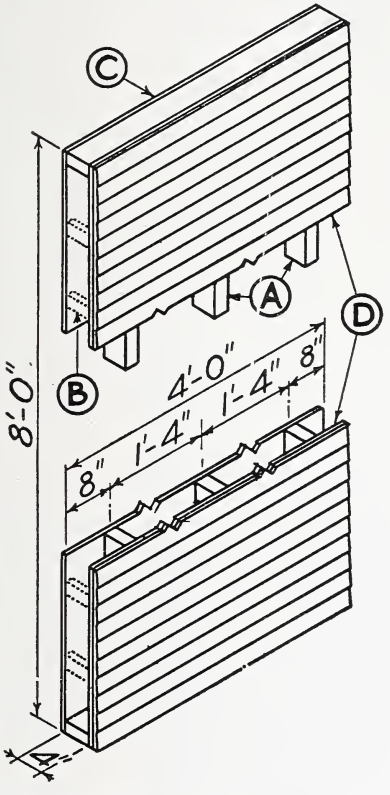
(*d*) *Building.*—An edifice formed by uniting materials into a self-supporting structure, as a dwelling.

Test Specimens

3. (*a*) *Size.*—The specimens shall be as large as practicable to minimize the effect of variations in the material and workmanship, and thereby obtain results representative of the construction in an actual house. Obviously, the size of the specimens shall be limited to the size that can be tested in the larger testing machines available in a well-equipped laboratory, that can be subjected to loads in accordance with good testing procedure, and for which the deformation can be measured with sufficient accuracy.

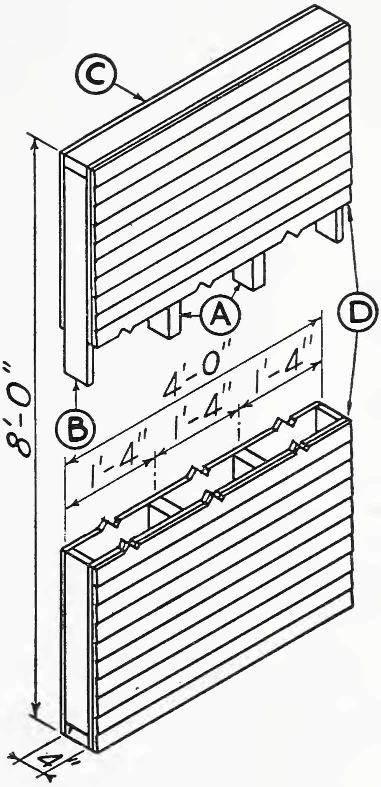
(*b*) *Length or Height.*—The length or height of specimen for each element shall be chosen to conform to the length or height of that element in a small house.

(*c*) *Width.*—The width of specimen shall be chosen, insofar as possible, to include several of the principal load-carrying members to ensure that the behavior under load will simulate that of a portion of a house under service conditions. With the exception of specimens for the racking load test, the nominal width of wall specimens shall be 4 ft. The actual width of specimens shall be a whole number multiplied by the spacing of the principal load-carrying members except for prefabricated panels, for which the actual width shall be the width of panel used in the house, if not over 4 ft. If the structural properties of a particular construction are to be compared with another construction, there should not be a great difference in the actual widths of the specimens (Note 1). For walls similar to conventional wood construction, having studs spaced 16 in., the actual width of the specimen shall be 4 ft. and shall include three studs. This specimen may have either three full-size studs as shown in Fig. 1, or two full-size studs and two half-thickness studs as shown in Fig. 2. If the specimen has three full-size studs, the overhanging faces may be tied together at intervals of about 1 ft. by filler blocks (Note 2), as shown by dotted lines in Fig. 1. Width of specimens of partitions, floors, and roofs also shall be 4 ft.



A—Three wood studs (2 by 4 in.).
B—Wood blocks to support the edges of the faces (optional).
C—Inside face (lath and plaster).
D—Outside face (wood sheathing, paper, and lap siding).

Fig. 1.—Typical Wall Specimen.



A—Two wood studs (2 by 4 in.).
B—Two wood "half" studs (1 by 4 in.).
C—Inside face (lath and plaster).
D—Outside face (wood sheathing, paper, and lap siding).

Fig. 2.—Typical Wall Specimen.

Note 1.—Under the impact load test a satisfactory comparison cannot be made if for one construction the specimens had an actual width of 2 ft. and for another 12 ft.

Note 2.—The filler blocks should prevent damage to the specimen when being shipped or handled and may remain in place when the specimen is tested, since their effect on the structural properties of the specimen will not be appreciable.

(*d*) *Age.*—Constructions, such as concrete and masonry (brick, structural clay tile, cement block), for which the structural properties depend upon the age of the specimen shall be tested not less than 25 days or more than 31 days after fabrication. This age requirement applies also to plastered and stuccoed constructions.

Loading

4. (*a*) The testing machine or load measuring apparatus shall comply with the requirements prescribed in the Tentative Methods of Verification of Testing Machines (ASTM Designation: E 4).[3]

(*b*) The rate of load application shall permit load and deformation readings to be observed accurately. For wood constructions, that is, constructions having wood structural members, the following rates of loading have been found satisfactory:

	Rate of Loading, in. per min
Compressive load, specimen 4 by 8 ft.	0.03
Transverse load, specimen 4 by 8 ft., span 7 ft. 6 in.	0.15
Concentrated load	0.05
Racking load, specimen 8 by 8 ft.	0.20

(*c*) The load shall be applied to all of the specimens in any test in increments so chosen that a sufficient number of readings will be obtained to determine definitely the load-deformation curve (see Section 61). The initial reading of the load and the reading of the deformation shall be recorded either with no load on the specimen or under a small initial load. The load shall be increased to the first increment and the deformation recorded. The load then shall be decreased to the initial load and the set (sometimes designated "permanent set") recorded. The load shall be increased to two increments and the set when it is released to the initial load recorded. This sequence of readings shall be followed for three increments, four increments, etc., of load. When for each specimen the behavior of the specimen under load indicates that the specimen might fail suddenly and damage the deformation-measuring apparatus, this apparatus shall be removed from the specimen and the load increased continuously until the maximum load that can be applied to the specimen is determined.

Deformation Measurements

5. The least reading in the measurements for deformation of specimens shall not exceed 0.01 in. The deformation measuring apparatus specified for any loading may be replaced by other apparatus, provided that it permits readings of deformation that are equivalent in accuracy to those from the specified apparatus.

TESTS OF WALLS

AXIAL LOADS

Axial Loads

6. Axial loads on walls may be either compressive load or tensile load. The compressive load test is covered in Sections 7 to 10, and the tensile load test is covered in Sections 11 to 14.

Compressive Load

Apparatus

7. The apparatus shall be assembled as shown in Fig. 3 and shall conform to the detailed requirements for component parts prescribed in Paragraphs (*a*) and (*b*), or the equivalent.

(*a*) *Compressometer.*—A bracket, *C*,

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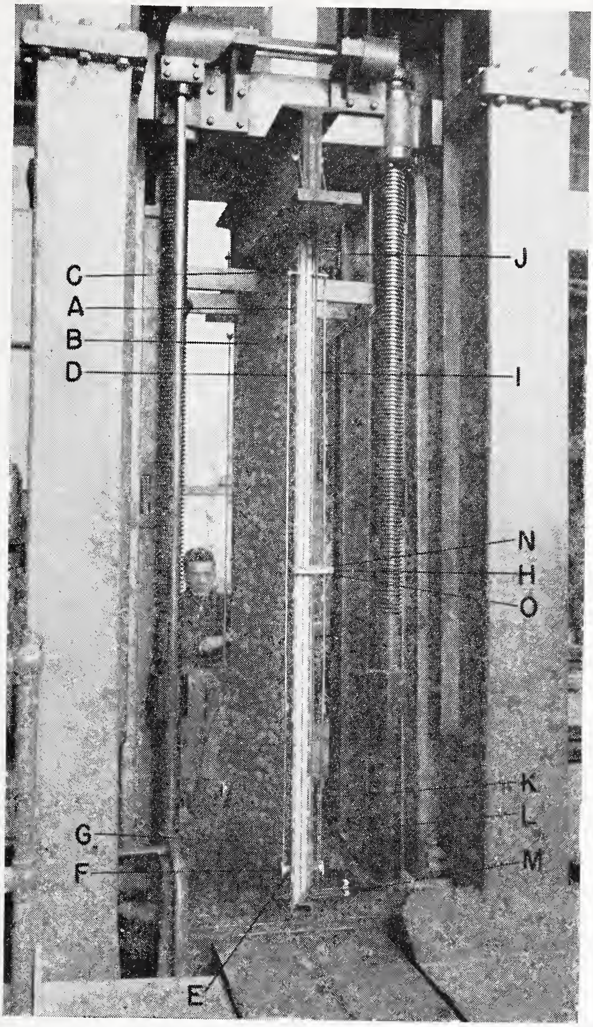
[3] See p. 418.

shall be attached to the specimen near the upper end, supporting a metal rod, *D*. A bracket, *E*, shall be attached to the specimen near its lower end, supporting a dial micrometer, *F*, with the spindle up. The conical end of the rod, *D*, shall seat in a hole in the end of the spindle and the rod and spindle shall be held in contact by stretched rubber bands, *G*. The dial shall be graduated to 0.001 in.



A—Compressometer.
B—Specimen.
C—Upper bracket.
D—Rod.
E—Lower bracket.
F—Dial micrometer.
G—Rubber bands.
H—Deflectometer.
I—Wire.
J—Upper clamp.
K—Lower end of wire.
L—Rubber bands.
M—Lower clamp.
N—Mirror.
O—Scale.

FIG. 3.—Apparatus for Compressive Load on Specimen.

(*b*) *Deflectometer*.—A small wire, *I*, shall be attached at its upper end to a clamp, *J*, near the upper end of the specimen. The lower end, *K*, connected to stretched rubber bands, *L*, shall be attached to a clamp, *M*, near the lower end of the specimen. A mirror, *N*, having a paper scale, *O*, one half the width of the mirror shall be attached horizontally to the edge of the specimen at mid-height. The scale shall be graduated to 0.1 in.

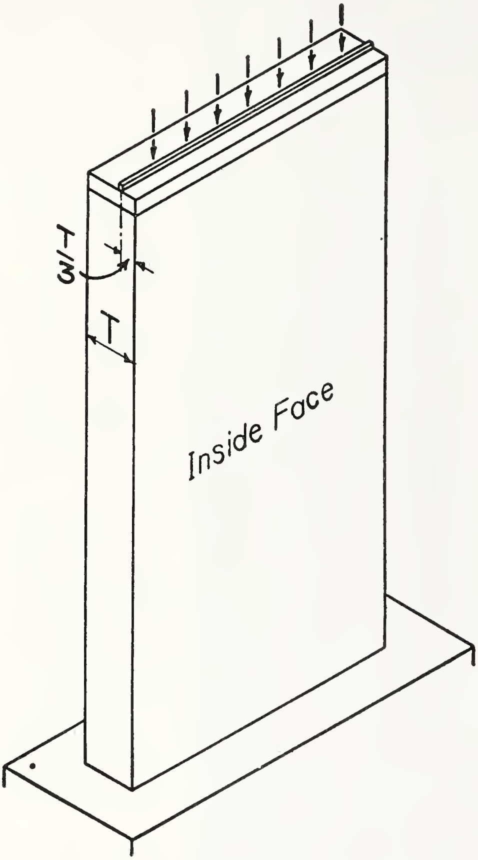


FIG. 4.—Compressive Load on Specimen.

Test Specimens

8. Tests shall be made on three duplicate specimens, each having a height of 8 ft. (Note) and a nominal width of 4 ft. (see Section 3).

NOTE.—A height of 8 ft. from floor to ceiling has been widely recognized as satisfactory for a small house. Therefore, the height of wall specimens for compressive load tests should be 8 ft. This is about the least height that can be used in a house. The actual height of a wall in a complete house may be somewhat greater than 8 ft., depending upon the connections between wall and floor, roof, etc. For a wall, as for any column, the greater the height, the less the compressive strength. Most walls for houses are column in the short, or intermediate class; therefore, the strength is about the same for any height used in a house. For some constructions, particularly thin walls, the compressive strength may decrease greatly with increase in height beyond 8 ft., and it may be necessary to determine the relation between the height and strength by making additional tests.

Procedure

9. (*a*) *Loading.*—The specimen shall be tested as a column having a flat end at the bottom (Fig. 4). Compressive loads shall be applied to a steel plate covering the upper end of the specimen. The load shall be applied uniformly along a line parallel to the inside face, and one third the thickness of the specimen from the inside face.

(*b*) *Load - Deformation Data.*—Four compressometers shall be attached to the faces of the specimen, *B*, one near each corner of the specimen, as shown in Fig. 3, to measure the shortening of the specimen. The readings shall be recorded to the nearest tenth of a division.

(*c*) *Lateral Deflection.*—Two deflectometers, *H*, shall be attached, one to each edge of the specimen, as shown in Fig. 3. The readings, when the image of the wire coincides with the wire, shall be recorded to the nearest tenth of a division.

Calculations and Report

10. (*a*) For each compressometer, the shortening under each load shall be calculated as the difference between the reading of the compressometer when the load is applied and the initial reading. The shortening of the specimen in 8 ft. shall be calculated as the average of the shortenings for each of the four com-

pressometers multiplied by the ratio: 8 ft. divided by the compressometer gage length. The sets shall be obtained in a similar manner.

(*b*) The lateral deflection and the lateral set under each load for each deflectometer shall be calculated as the difference between the reading of the deflectometer when the load is applied and the initial reading. The lateral deflection and lateral set for the specimen shall be calculated as the average of the lateral deflection and lateral set of the two deflectometers.

(*c*) The maximum load for each specimen shall be recorded and the results of load - deformation and load - deflection measurements shall be reported in the form of a graph in accordance with Section 61.

Tensile Load

Apparatus

11. The apparatus preferably shall be assembled in a vertical testing machine and shall conform to the detailed requirements for component parts prescribed in Section 7 (*a*) and (*b*), or the equivalent, with the exception that the compressometers prescribed in Section 7 (*a*) shall be replaced by extensometers which shall be like the compressometers but so adjusted before load is applied that the stretch of the specimen can be measured.

Test Specimens

12. Tests shall be made on three duplicate specimens, each having a height of 8 ft. and a nominal width of 4 ft. (see Section 3). The specimens for tensile load tests shall be of the same "construction" as the specimens for compressive load tests (see Section 2 (*c*)).

Procedure

13. (*a*) *Loading.*—The specimen shall be tested as a tension specimen by uniform application of tensile forces along the line of the fastenings at the top and the bottom of wall in a building. The top and bottom pulling fixtures may be attached to the specimen by fastenings similar to those used in a building, provided that, under the maximum load, failure of the specimen occurs between the top and the bottom of the specimen—not in either the pulling fixtures or the fastenings (Note).

For Masonry Constructions.—The construction may be continued upward beyond the top of the specimen and downward below the bottom of the specimen to enclose attachments for the pulling fixtures.

For Framed Wall Constructions.—If the construction has studs (either of wood or metal) the studs may be extended upward and downward beyond the top and the bottom of the specimen and attached to the pulling fixtures. If the framed wall has plates at the top and the bottom, the pulling fixtures shall be attached to the plates in the specimen.

NOTE.—If, under the tensile load, failure occurs either in a pulling fixture or in a fastening, the results of the test determine only the properties of the fixtures or the fastenings—*not* of the wall construction. When the failure occurs in fastenings, the tensile load indicates the maximum tensile strength of the construction that can be realized in actual service unless improved fastenings are provided.

(*b*) *Load - Deformation Data.*—Four extensometers shall be attached to the faces of the specimen. *B*, one near each corner, as shown in Fig. 3, to measure the stretch of the specimen. The readings shall be recorded to the nearest tenth of a division.

(*c*) *Lateral Deflection.*—Two deflectometers, *H*, shall be attached, one to each edge of the specimen, as shown in Fig. 3. The readings, when the image of the wire coincides with the wire, shall be recorded to the nearest tenth of a division. Lateral deflection (if any) may be caused by nonaxial loading of the specimen.

Calculations and Report

14. For tensile loads, the calculations and report shall be similar to those required for compressive loads (see Section 10).

TRANSVERSE LOAD

Test Specimens

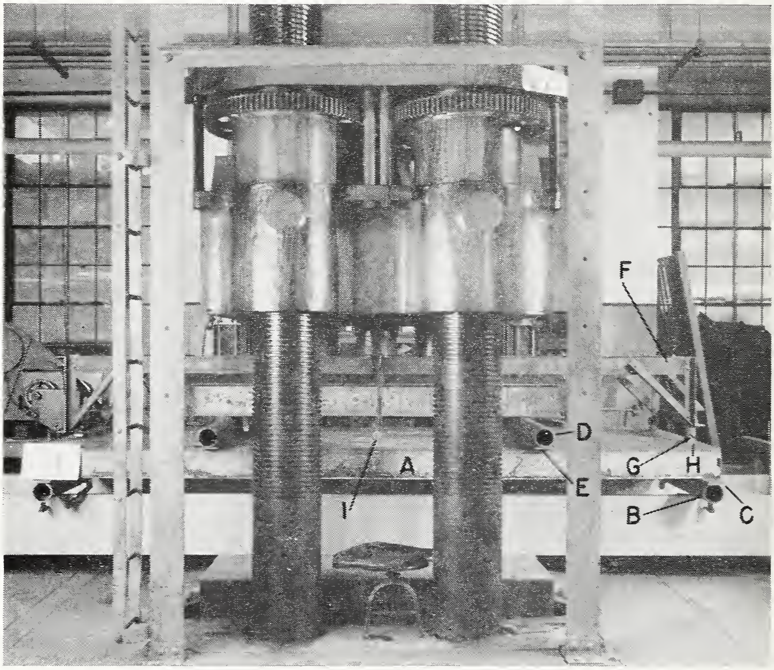
15. Tests shall be made on six duplicate specimens each having a height (Note) of 8 ft. and a nominal width of 4 ft. (see Section 3). The specimens for transverse load tests shall be of the same "construction" as the specimens for axial load tests (see Section 2 (*c*)).

NOTE.—As it appears desirable to avoid unnecessary differences in the heights of the wall specimens, 8 ft. is selected for the height of the wall specimen for transverse load. Necessarily, the span is slightly less than 8 ft.

Method A. Specimen Horizontal

Apparatus

16. The apparatus shall be assembled as shown in Fig. 5 and shall conform to the detailed requirements for component parts prescribed in Paragraphs (*a*) to (*c*), or the equivalent.



A—Specimen.
B—Supporting roller.
C—Plate.
D—Loading roller.
E—Plate.
F—Frame.
G—Ball.
H—Blocks.
I—Dial micrometer.

FIG. 5.—Apparatus for Transverse Load on Specimen Tested Horizontally.

(*a*) *Supports.*—Two steel rollers, *B*, with a steel plate, *C*, between each supporting roller and the specimen.

(*b*) *Loading Assembly.*—Two steel rollers, *D*, with a steel plate, *E*, between each loading roller and the specimen.

(*c*) *Deflection Gage.*—A frame, *F*, shall be placed on the upper face of the specimen. To prevent stresses deforming the frame as the specimen deforms under load, this frame shall rest on three hardened steel balls, *G*, each supported by a steel block, *H*, on the face of the specimen. Two of the balls shall be placed in a line vertically above one support and the third ball vertically above the other support. One foot of the frame is thus free to rotate about a point, one to move along a line, and one to move in a plane; the frame, therefore, is kinematically nonredundant or stress-free. Two dial micrometers, *I*, one near each longitudinal edge of the specimen, shall be attached to the frame, *F*, at mid-span. The spindles shall rest on the upper face of the specimen. The micrometers shall be graduated to 0.001 in.

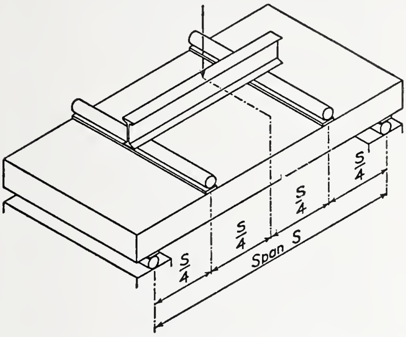
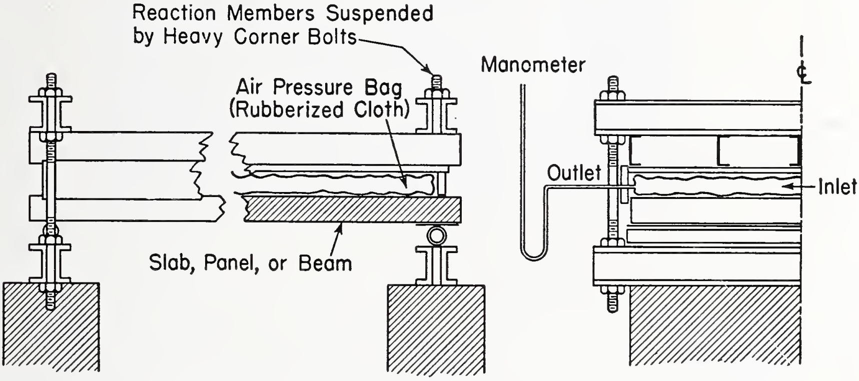


FIG. 6.—Transverse Load on Specimen.

Procedure

17. (*a*) *Loading.*—"Two-point" loading shall be used for transverse load tests (Note 1). The specimen shall be tested as a simple beam (Fig. 6) on a span, *S*, of 7 ft. 6 in. Two equal loads shall be applied, each at a distance of one quarter of the span from the supports, toward the middle of the span (Note 2). For wall specimens tested horizontally, (Fig. 5), the load on the specimen shall include the weight of specimen between the supports. The transverse loads shall be applied to the outside face for three of the specimens, and to the inside face for three of the specimens.

NOTE 1.—Uniformly distributed loading may be used in lieu of quarter point loading, if a satisfactory method is available. The transverse strength for any span may be greater for some constructions under uniformly distributed load than under loads applied at the quarter points of the span. Transverse load, uniformly distributed, may be applied by air pressure, either in a bag or in a chamber having the specimen as one face. Specimens tested under uniform loading shall be supported by rollers as for quarter-point loading. Wall specimens may be either horizontal or vertical.



Reaction Members Suspended by Heavy Corner Bolts
Air Pressure Bag (Rubberized Cloth)
Slab, Panel, or Beam
Manometer
Outlet
Inlet
℄

FIG. 7.—Apparatus for Uniformly Distributed Transverse Load—Bag Method.

Bag Method.—This method is shown schematically in Fig. 7. A reaction platform parallel to the face to be loaded and wider than the specimen shall be connected to the supports by tie rods. An airtight bag of rubberized cloth as wide as the specimen and as long as the span shall be placed between the specimen and reaction platform. Transverse load shall be applied to the specimen by increasing the air pressure in the bag. The pressure shall be measured by means of a manometer. Water is usually the liquid in the manometer, but the specific gravity of the liquid shall be such that the error in pressure readings does not exceed 1 per cent.

Chamber Method:

Specimen Horizontal.—For this method the specimen shall be placed near the floor, which should be practically airtight. An airtight frame or curb shall surround the specimen closely and be about flush with the upper surface of the specimen. A rubber blanket covers the specimen, overlaps the frame, and is sealed so that it is reasonably airtight. A small vacuum pump or positive action exhaust blower is used to reduce air pressure between the specimen and floor. The difference in pressure above and below the specimen is measured by means of a manometer.

Specimen Vertical.—For this method the specimen forms one face of an airtight chamber from which the air is exhausted. If all four edges of the specimen bear on the chamber, this loading determines the strength of the specimen as a plate supported at the four edges, not the transverse strength as defined in these methods.

If a specimen tested by the "chamber method," either horizontally or vertically, has an airtight cavity, each cavity shall be vented to the low-pressure face by a hole in the face of the specimen not less than ⅛ in. in diameter, located where it will least affect the transverse strength of the specimen.

Note 2.—Under two-point loading the bending moment is constant for the portions of the specimen between the two loads, a longitudinal distance of one half the span. This bending moment is equal to the bending moment that would exist at mid-span if the total load were uniformly distributed over the face of the specimen between the supports. The vertical shear is constant for the two portions of the specimen between each load and the adjacent support. This shear is equal to the shear which would exist at the supports if the total load were uniformly distributed over the face of the specimen between the supports. Under the "two-point" loading, much larger portions of the specimen are subjected to the maximum bending moment and to the maximum shear than if the same total load were uniformly distributed over the face of the specimen between the supports. The deflection at mid-span, however, is not equal to the deflection if the load were uniformly distributed. The deflection under uniformly distributed load can be estimated with sufficient accuracy for practical purposes by the usual engineering methods if deflections are known for the concentrated loading, or the deflection can be measured under a uniformly distributed load.

(*b*) *Strength on Short Span.*—The transverse strength of any construction increases as the span is shortened. If the strength of the construction for a shorter span is desired, it shall not be computed, but the construction shall be tested on the short span.

Calculations and Report

18. (*a*) For each micrometer, the deflection under a given load shall be calculated as the difference between the reading to the nearest division of the micrometer when the load is applied and the initial reading. The deflection of the specimen, for the span of 7 ft., 6 in., shall be calculated as the average of the deflections obtained from each of the two micrometers. The sets under the initial load shall be calculated by using a similar method. The maximum load for each specimen shall be recorded.

(*b*) The results shall be reported in the form of a graph in accordance with Section 61.

Method B. Specimen Vertical—for Masonry Constructions

Apparatus

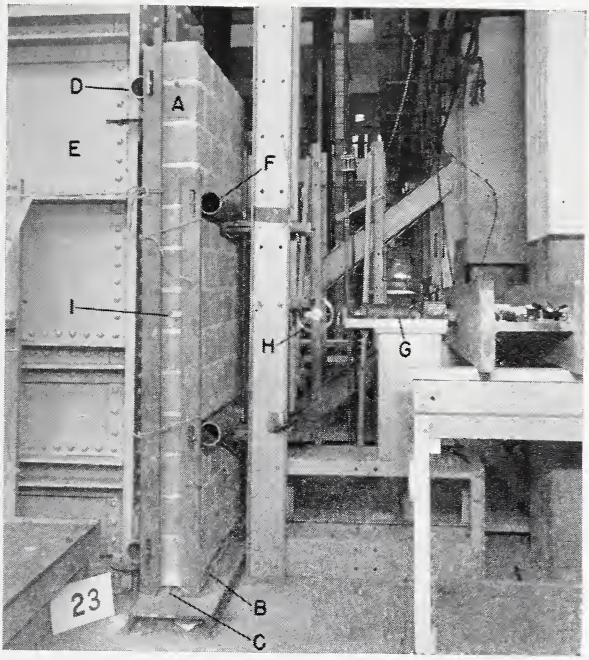
19. The apparatus shall be assembled as shown in Fig. 8 and shall conform to the requirements for component parts prescribed in Paragraphs (*a*) to (*e*), or the equivalent.

(*a*) *Steel Channel.*—Steel channel, *B*.

(*b*) *Rollers.*—Cylindrical rollers, *C*; two supporting rollers, *D*; two loading rollers, *F*.

(*c*) *Screw Jack.*—Screw jack, *G*.

(*d*) *Ring Dynamometer.*—Ring dynamometer, *H*.



A—Specimen.
B—Channel.
C—Roller.
D—Supporting roller.
E—Frame.
F—Loading roller.
G—Screw jack
H—Ring dynamometer.
I—Deflectometer.

Fig. 8.—Apparatus for Transverse Load on Specimen Tested Vertically.

(*e*) *Deflectometers.*—Two taut-wire mirror-scale deflectometers, *I*, similar to those described in Section 7 (*b*).

Procedure

20. (*a*) Transverse loads cannot be applied satisfactorily to some wall constructions, such as masonry, with the specimen in a horizontal position. For such constructions, the loads shall be applied with the specimen in a vertical position, as shown in Fig. 8, thus simulating service conditions. The specimens, *A*, on a steel channel, *B*, shall rest on cylindrical rollers, *C*, to prevent restrained end conditions. The axes of the rollers shall be parallel to the faces of the specimen. The two supporting rollers, *D*, shall be in contact with the vertical surface of the frame, *E*, and each roller shall rest horizontally on sponge rubber about $\frac{1}{2}$ in. thick to prevent longitudinal restraint. Each of the two loading rollers, *F*, shall also rest on sponge rubber. The loads shall be applied horizontally by a screw jack, *G*, and measured by a ring dynamometer, *H*, between the jack and the specimen. The error in the load indicated by the dynamometer shall not exceed 1 per cent. Two taut-wire mirror-scale deflectometers, *I*, shall be attached to the specimen, one to each vertical edge.

(*b*) The transverse load shall be applied to the outside face for three of the specimens, and to the inside face for three of the specimens.

Calculations and Report

21. The results of test shall be calculated and reported as described in Section 18.

Concentrated Load

Method A

Apparatus

22. The apparatus shall be assembled as shown in Fig. 9 and shall conform to the requirements for component parts prescribed in Paragraphs (*a*) to (*f*), or the equivalent.

(*a*) *Steel Disk.*—Steel disk, *B*, having a diameter of 1 in. and the lower edge rounded to a radius of 0.05 in.

(*b*) *Screw.*—Screw, *C*, for applying load.

(*c*) *Ratchet Wrench.*—Ratchet wrench, *D*.

(*d*) *Spring Dynamometer.*—Spring dynamometer, *E*, with capacity of 500 lb., having as the principal elements a helical steel spring and a dial micrometer.

(*e*) *Ring Dynamometer.*—Ring dynamometer, *F*, with capacity of 20,000 lb., having as the principal elements a heat-treated steel ring and a dial micrometer.

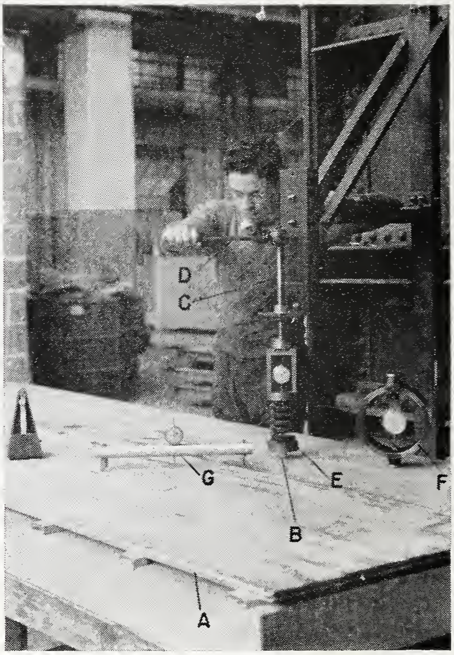
(*f*) *Depth Gage.*—The depth gage, *G*, shall consist of a light tubular frame having two legs at one end and one leg at the other end. The span shall be 12 in. There shall be a dial micrometer graduated to 0.001 in. attached to the frame at mid-length.

Test Specimens

23. Concentrated load tests shall be made on each transverse specimen after the transverse load tests, the concentrated load being applied to the same face to which the transverse load was applied.

Procedure

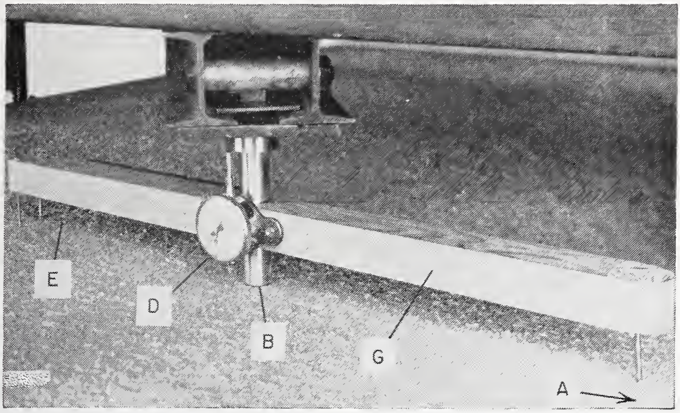
24. (*a*) *Loading.*—The entire specimen or a portion of the specimen, *A*, shall be placed on a horizontal support (see Fig. 9). The steel disk, *B*, shall be placed on the face of the specimen at what is judged to be the weakest place and, also, at what is judged to be the strongest place. A load shall be applied vertically downward to the upper surface of the disk by the screw, *C*, which can be rotated by the ratchet wrench, *D*. To measure the load, either the spring dynamometer, *E*, or the ring dynamometer, *F*, shall be placed between the disk, *B*, and the lower end of the screw, *C*. The error in the load in-



A—Specimen.
B—Disk.
C—Screw.
D—Wrench.
E—Spring dynamometer.
F—Ring dynamometer.
G—Depth gage.

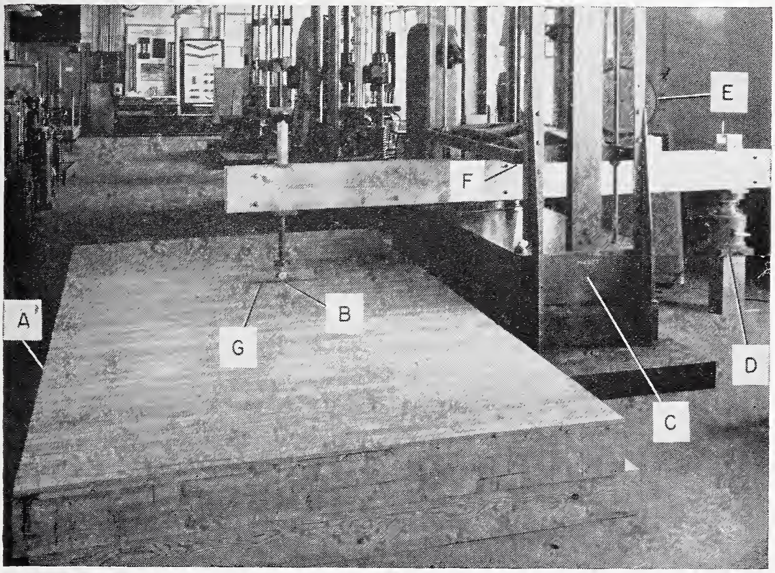
Fig. 9.—Apparatus for Concentrated Load on Specimen—Method A.

dicated by either of these dynamometers shall not exceed 1 per cent. The shortening of the spring, or the shortening of the vertical diameter of the ring, under compressive loads is indicated on the dial of the micrometer. Loading shall be continued until maximum load or 1000 lb. is attained.



A—Specimen.
B—Disk.
D—Dial micrometer.
E—Three-legged support.
G—Depth gage.

FIG. 10.—Apparatus for Concentrated Load on Specimen—Method B.



A—Wood floor.
B—Disk.
C—Testing machine for applying load.
D—Hydraulic capsule.
E—Pressure scale for measuring load.
F—Fulcrum for wood beam.
G—Depth gage.

FIG. 11.—Concentrated Load Applied to Wood Floor by Method B.

(*b*) *Depth of Indentation.*—Readings shall be taken with the depth gage in two positions: first, with the frame of the depth gage parallel to the height of the specimen, and second, with the frame at right angles to the height. The average of these two readings shall be taken as the reading of the depth gage. The micrometer shall be read to the nearest division. Before the concentrated load is applied, the location of the weakest place and of the strongest place shall be marked on the face of the specimen. For each of these locations the depth gage shall be placed on the face of the specimen with the spindle of the micrometer on the load mark: first, with the frame parallel to the height of the specimen, and second, with it at right angles to the height, and the reading of the micrometer recorded. Before the depth gage is removed the location of each leg shall be marked on the face. After the depth gage is removed, the disk, B, shall be placed on the load mark, the load applied and then released, and the disk removed. The depth gage again shall be placed on the specimen with each leg on its previous leg mark, thereby bringing the spindle of the micrometer to the center of the indentation.

Calculations and Report

25. (*a*) The depth of the indentation (set) after a given load has been applied and the disk removed shall be calculated as the difference between the depth for that load and the initial reading of the micrometer before a load has been applied to the specimen.

(*b*) The results shall be reported in the form of a graph in accordance with Section 61.

Method B

Apparatus

26. The apparatus shall be assembled as shown in Fig. 10, and shall conform to the requirements for component parts prescribed in Paragraphs (*a*) to (*c*), or the equivalent.

(*a*) *Steel Disk, B.*—See Section 22 (*a*).

(*b*) *Depth Gage.*—The depth gage, *G*, shall consist of a dial micrometer, *D*, mounted on a three-legged support, *E*. The support shall be notched to permit placing the micrometer directly adjacent to the disk and shall be long enough to permit placing the supporting legs on undisturbed areas of the face of the specimen.

(*c*) *Loading Device.*—Any convenient means for applying a compressive load up to 1000 lb. and means for measuring the load within 1 per cent. One example of a loading device with depth gage for Method B is shown in Fig. 11.

Test Specimens

27. Concentrated load tests shall be made on each transverse specimen after the transverse tests, the concentrated load being applied to the same face to which the transverse load was applied.

Procedure

28. (*a*) *Loading.*—The entire specimen or portion of the specimen, *A*, shall be placed on a horizontal support. The steel disk, *B*, shall be placed on the face of the specimen at what is judged to be the weakest place and, also, at what is judged to be the strongest place. A load shall be applied vertically downward to the upper surface of the disk. Loading shall be continued until maximum load or 1000 lb. is attained.

(*b*) *Depth of Indentation.*—The depth of indentation shall be measured, by means of the depth gage, *G*, and the reading of the micrometer recorded to the nearest division.

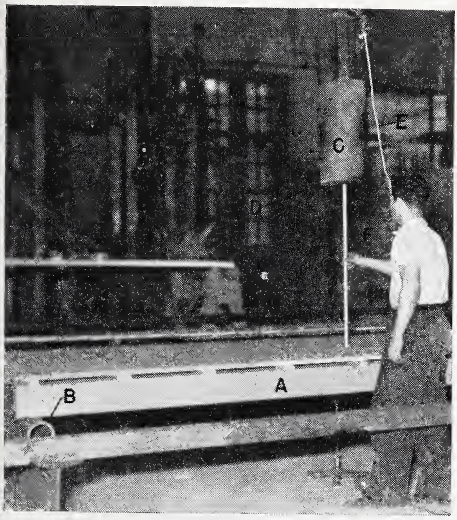
Calculations and Report

29. The calculations and report shall be similar to those required for Method A (see Section 25).

IMPACT LOAD

Test Specimens

30. (*a*) Tests shall be made on six duplicate specimens each having a height of 8 ft. and a nominal width of 4 ft. (see Section 3). The impact load shall be applied to the outside face for three of the specimens, and to the inside face for three of the specimens. Except for the alternative arrangement of structural members (studs) in Paragraph (*b*), the specimens for impact load tests shall be of the same "construction" as the specimens for axial load and transverse load tests (see Section 2 (*c*)).



A—Specimen.
B—Supporting roller.
C—Sandbag.
D—Bottom disk.
E—Trip cord.
F—Height-measuring stick.

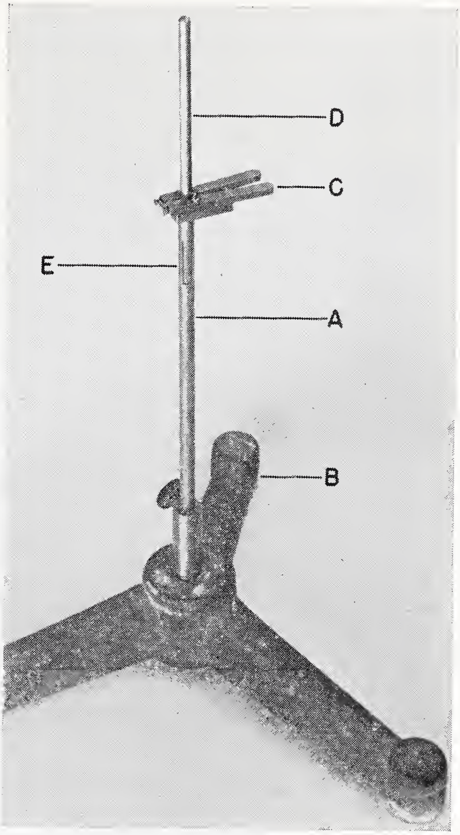
FIG. 12.—Apparatus for Impact Load on Specimen Tested Horizontally.

(*b*) *Point of Impact.*—If the wall construction has structural members (studs) the specimens shall be built with a member at mid-width where it will be struck by the sandbag, or the specimen may be built with two members equidistant from mid-width, so that the sandbag will strike the facing midway between members.

Method A. Specimen Horizontal

Apparatus

31. The apparatus shall be assembled as shown in Figs. 12 to 14 and shall conform to the detailed requirements for component parts prescribed in Paragraphs (*a*) to (*f*), or the equivalent.



A—Tube.
B—Base.
C—Friction clamp.
D—Rod.
E—Fiduciary mark.

FIG. 13.—Deflectometer for Measuring Instantaneous Deflection of Specimen Under Impact Loads.

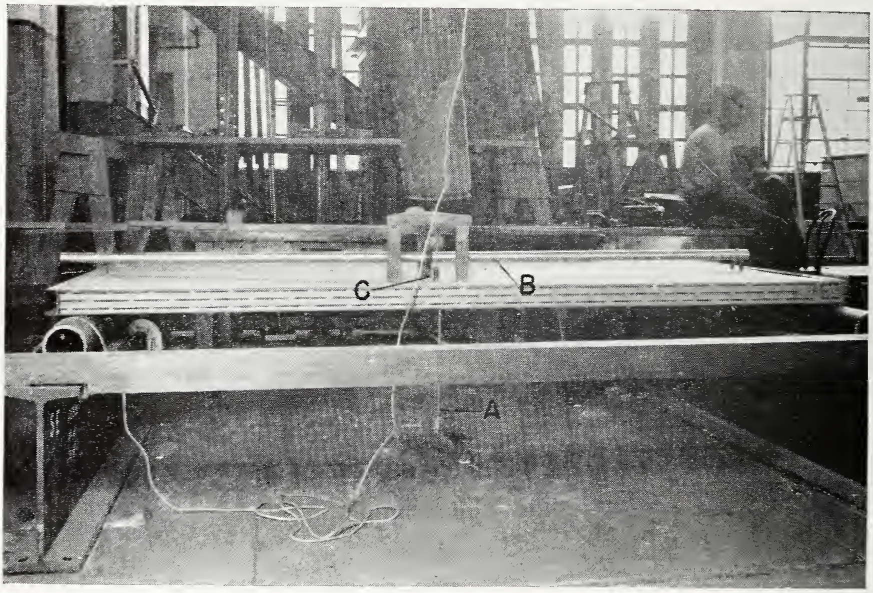
(*a*) *Supports.*—Two steel rollers, *B* in Fig. 12.

(*b*) *Sandbag.*—The sandbag (Note) shall not be less than 9 in. in diameter and shall not exceed 10½ in. in diameter. It shall weigh 60 lb. The weight shall be adjusted to this value before each series of impact tests. Before testing a specimen, the bag shall be rolled on the floor to loosen the sand and obtain, insofar as possible, constant conditions.

NOTE.—Bags made to the following specifications have given satisfactory service: The wall of the bag shall be made from "Indian-tanned" lace leather, type *B*, Federal Specification for Leather; Lace (KK-L-201a).[4] It shall be 28 in. in height by 29 in. in width. The vertical edges shall be sewed together flesh side out. The bag then shall be turned hair side out and one end sewed to disk, *D*, which shall be 9 in. in diameter and shall be made from harness or belting leather $\frac{3}{16}$ in. in thickness. All seams shall be stitched with linen shoe thread, using two rows of stitching.

For use in hoisting the bag, a strap $\frac{1}{8}$ in. in thickness, $\frac{5}{8}$ in. in width, and 24 in. in length, having a buckle at one end and holes near the other end, shall be passed through two diametrically opposite holes in the bag $1\frac{1}{2}$ in. from the upper end and buckled. There shall be two reinforcements sewed to the bag on the inside, one at each hole. The reinforcements shall be 3 in. square and shall be made of the same leather as the bag.

Sand shall be placed in a cloth bag, which shall be securely tied and placed inside the leather bag.



A—Deflectometer
B—Set gage.
C—Gage block.

FIG. 14.—Apparatus for Impact Load on Specimen Tested Horizontally.

(*c*) *Measuring Sticks*.—A stick, *F* in Fig. 12, laid off in 6-in. increments, or a series of sticks the lengths of which are multiples of 6 in., shall be used to accurately measure the height of drop.

(*d*) *Deflectometer*.—The deflectometer (Fig. 13) shall consist of a metal tube, *A*, having a base, *B*, at the lower end and a friction clamp, *C*, at the upper end. A light metal rod, *D*, movable in the tube, shall be held in contact with the middle of the lower face of the specimen by the clamp. The rod, *D*, shall be graduated to 0.1 in.

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[4] This material is available from J. B. Williams & Sons, Dover, N. H.

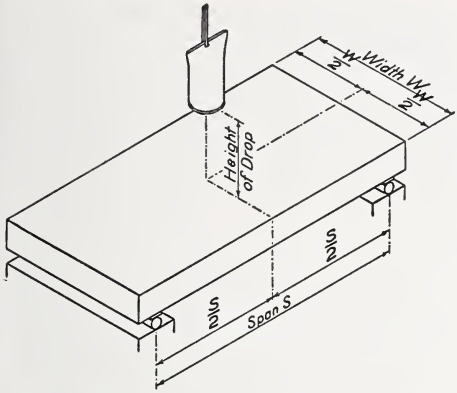
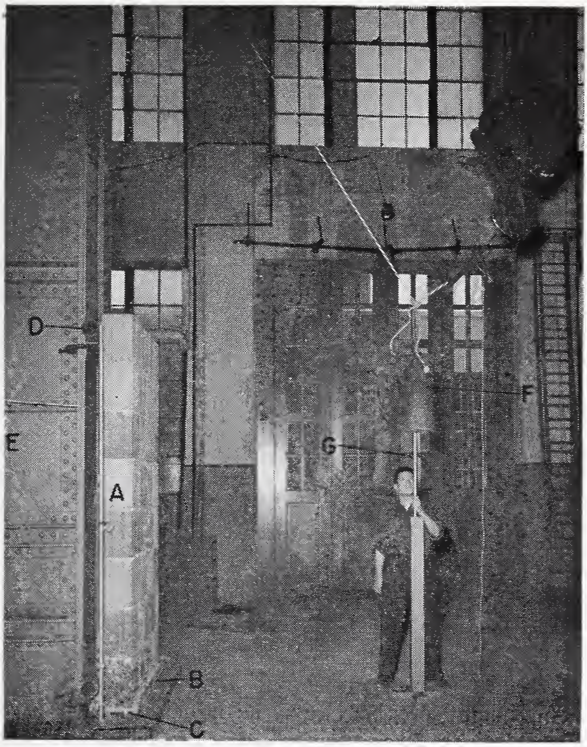


FIG. 15.—Impact Load on Specimen.

(*e*) *Set Gage.*—The set gage, *B* in Fig. 14, shall consist of a light, rigid frame having two legs at one end and one leg at the other end, with the distance between the legs equal to the span of the specimen. A dial micrometer graduated to 0.001 in. shall be attached to the frame at mid-length.

(*f*) *Gage Blocks.*—Gage blocks, *C* in Fig. 14.

Procedure



A—Specimen.
B—Channel.
C—Roller.
D—Supporting roller
E—Frame.
F—Sandbag.
G—Height-measuring stick

FIG. 16.—Apparatus for Impact Load on Specimen Tested Vertically.

32. (*a*) *Loading.*—The specimen shall be tested, as shown in Fig. 15, as a simple beam on a span of 7 ft. 6 in. The two supports for the specimen, *A* in Fig. 12, prevent longitudinal restraint. An impact load shall be applied to the middle of the upper face of the specimen by dropping the sandbag, C. When making a test (Fig. 12), the bag shall be hoisted, then released by pulling the

trip cord, *E*, when the bag is at the desired height. For the first drop, the height of the bag shall be measured from the upper face of the specimen, and for subsequent drops, from a taut cord in contact with the face vertically above the supports. The height of the bag shall be indicated by the series of sticks, *F*. The impact loads shall be applied to the outside face for three of the specimens, and to the inside face for three of the specimens.

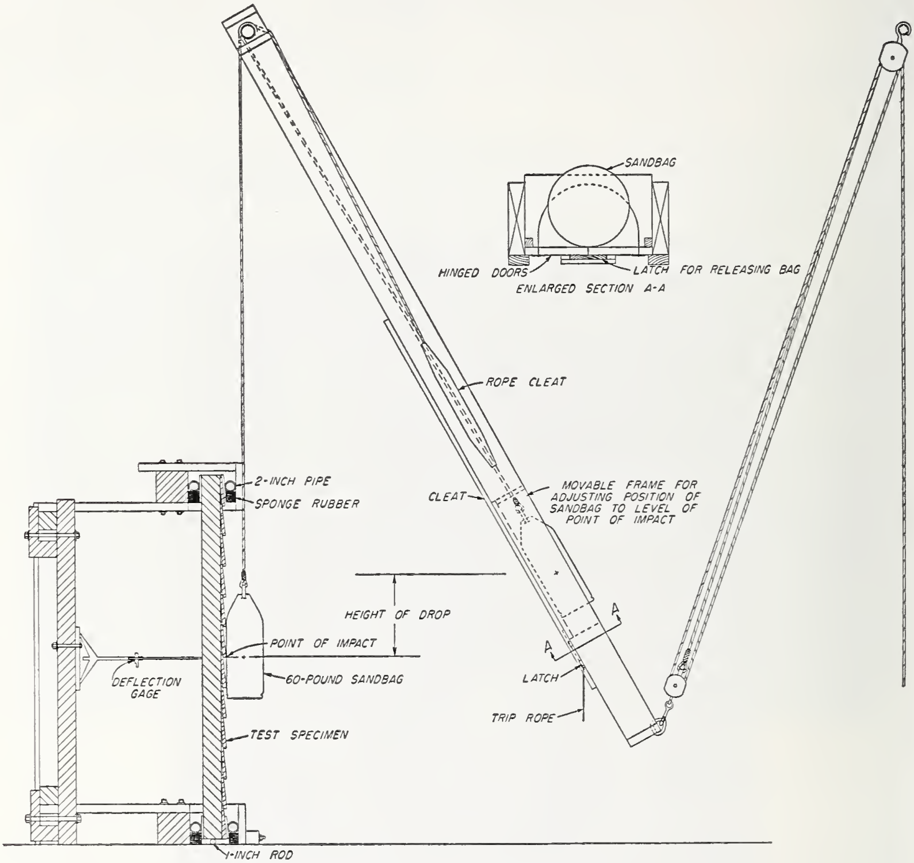


Fig. 17.—Frame for Sandbag.

(*b*) *Instantaneous Deflection.*—To measure the instantaneous deflection of the specimen, the deflectometer shown in Fig. 13 shall be used. The deflectometer shall be placed on the floor under the specimen as shown at *A* in Fig. 14. When the specimen deflects under the impact load the rod, *D*, is held in its lowest position. Readings relative to the fiduciary mark, *E*, on the tube, *A*, shall be estimated to 0.1 division.

(*c*) *Set.*—To measure the set, the set gage, *B* in Fig. 14, shall be placed on the upper face of the specimen. Readings shall be taken as shown in Fig. 14 by placing the set gage on the specimen with the legs vertically above the supports and the spindle of the dial micrometer in contact with the middle of the specimen, and reading the micrometer. If the set exceeds the range of the micrometer, gage blocks, *C*, shall be placed between the specimen and the spindle of the micrometer. The readings on the micrometer shall be recorded to the nearest division.

NOTE.—For some specimens, the upper face may be fractured by the impact of the sandbag while the lower face remains unfractured; therefore, the set measured to the upper face may be greater than the deflection measured to the lower face.

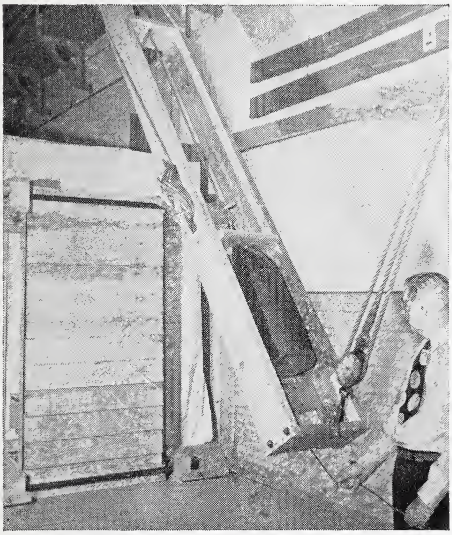


FIG. 18.—Impact Load on Wood Wall, Showing Frame for Sandbag.

Calculations and Report

33. (*a*) For each height of drop the deflection shall be calculated as the difference between the reading of the deflectometer and the initial reading. Similarly, the set shall be calculated as the difference between the reading of the set gage and the initial reading. The maximum height of drop shall be recorded, provided this height of drop does not exceed 10 ft.

(*b*) The results shall be reported in the form of a graph in accordance with Section 61.

Method B. Specimen Vertical—for Masonry Constructions

Apparatus

34. The apparatus shall be assembled as shown in Fig. 16 and shall conform to the detailed requirements for component parts prescribed in Paragraphs (*a*) to (*c*), or the equivalent.

(*a*) *Steel Channel.*—Steel channel, *B*

(*b*) *Rollers.*—Cylindrical rollers, *C*, and two supporting rollers, *D*.

(*c*) *Sandbag, Measuring Sticks, Deflectometer, Set Gage, and Gage Blocks.*—See Section 31 (*b*) to (*f*).

Procedure

35. (*a*) *Loading.*—For wall constructions, such as masonry, to which impact loads cannot be applied satisfactorily with the specimen in a horizontal position, the loads shall be applied with the specimen in a vertical position, as shown in Fig. 16, thus simulating service conditions. The specimen, *A*, on a steel channel, *B*, shall rest on cylindrical rollers, *C*, to prevent restraint. The axes of the rollers shall be parallel to the faces of the specimens. The two supporting rollers, *D*, shall be in contact with the vertical surface of the frame, *E*, and each roller shall rest horizontally on sponge rubber about $\frac{1}{2}$ in. thick to prevent longitudinal restraint. The impact load shall be applied to the middle of the face of the specimen by the sandbag, *F*, weighing 60 lb., as described in Section 31 (*b*). The bag shall be supported as a pendulum in the frame as shown in Fig. 17. The height of drop shall be measured from the point of impact of the center of gravity of the bag where it strikes the specimen to this

same point when the bag is in the raised position. The bag shall be released by suddenly opening the hinged doors, thus eliminating wobbling of the bag and causing it to swing as a true pendulum. The apparatus arranged for impact load on a wood wall is shown in Fig. 18.

(*b*) *Deflection.*—The deflection under the impact load and the set shall be measured as described in Section 32 for the impact tests on specimens in the horizontal position.

Calculations and Report

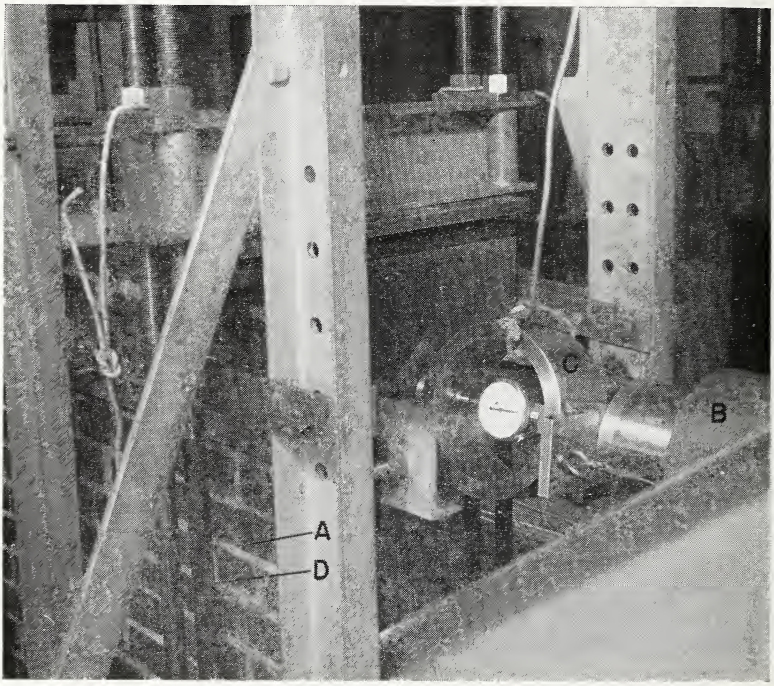
36. Using the readings taken in accordance with Section 35, the results shall be calculated and reported as described in Section 33.

RACKING LOAD

Method A. For Evaluation of Complete Assemblies.

Apparatus

37. The apparatus shall be assembled as shown in Figs. 19 and 20, and shall conform to the detailed requirements for component parts prescribed in Paragraphs (*a*) to (*d*), or the equivalent.



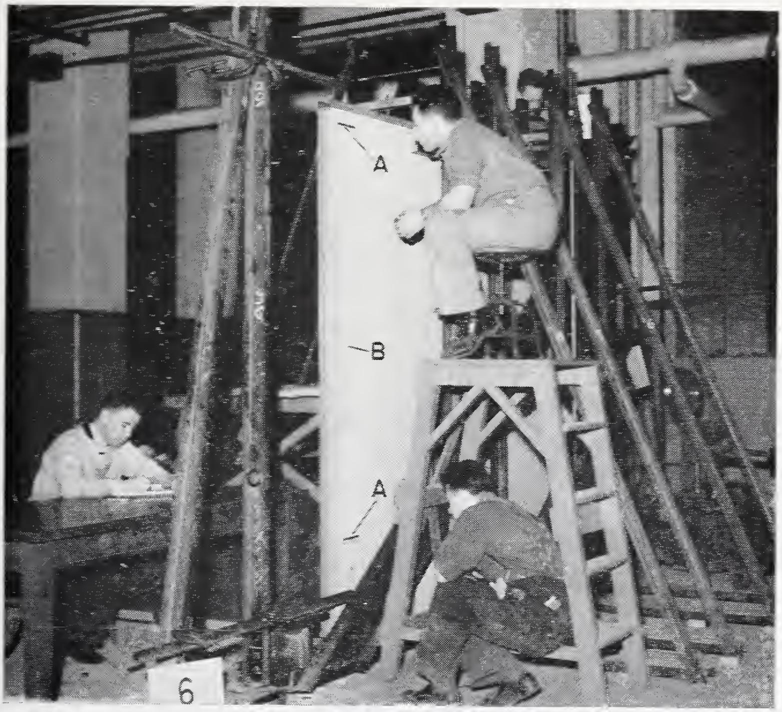
A—Specimen.
B—Hydraulic jack.
C—Ring dynamometer.
D—Tie rod.

FIG. 19.—Racking Load Equipment.

(*a*) *Hydraulic Jack.*—Hydraulic jack, *B*, with capacity of 50,000 lb.

(*b*) *Ring Dynamometer.*—Ring dynamometer, *C*, with capacity of 50,000 lb.

(*c*) *Deflectometers.*—For measuring horizontal deformation, two mirror-scales, *A*, shall be attached horizontally to one face of the specimen, as shown in Fig. 20, one near the upper end and the other near the lower. A vertical wire, *B*, shall be attached to the frame, *C*, and tension in the wire shall be maintained by stretched rubber bands. The frame, *C*, resting on the floor shall be moved to position the wire near the mirror-scales. A taut-wire mirror-scale device having the wire horizontal shall be attached to the specimen to measure vertical movement of the edge to which the load is applied.



A—Mirror scale.
B—Wire.
C—Frame.

FIG. 20.—Apparatus for Racking Load on Specimen.

(*d*) *Tie Rods.*—Two tie rods, *D*.

Test Specimens

38. Tests shall be made on three duplicate specimens, each having a height of 8 ft., and a nominal width of 8 ft. (see Section 3). Except for width, the specimens for racking load tests shall be of the same "construction" as the specimens for axial load, transverse load, and impact load tests (see Section 2 (*c*)).

NOTE.—A nominal width of 8 ft., twice the width of the wall specimens for the other tests, has been chosen because the less the width, the greater the vertical forces on the upper and lower ends required to prevent rotation of the specimen under a racking load.

Procedure

39. (*a*) *Loading.*—The specimen shall be tested as shown in Fig. 21, supported along its base with a block at one end as shown to prevent horizontal movement when the racking load is applied. There shall be two tie rods at the opposite end, one on each side of the specimen to prevent an upward movement of this edge of the specimen. There shall be two steel plates separated by rollers be-

tween the upper end of the specimen and the plate on the tie rods to prevent horizontal restraint. The racking load shall be applied near the upper end of the specimen to produce the shearing stresses. The racking load shall be applied horizontally to the specimen, *A* in Fig. 19, by the hydraulic jack, *B*, or by other equivalent means. To measure the load, the ring dynamometer, *C*, shall be placed between the jack and the specimen. The error in the load indicated by the dynamometer shall not exceed 1 per cent. Horizontal movement of the specimen under the racking loads shall be prevented by the stop, *A*, as shown in Fig. 22. The stop shall be bolted to the base of the racking frame, with plates between the end of the specimen and the stop.

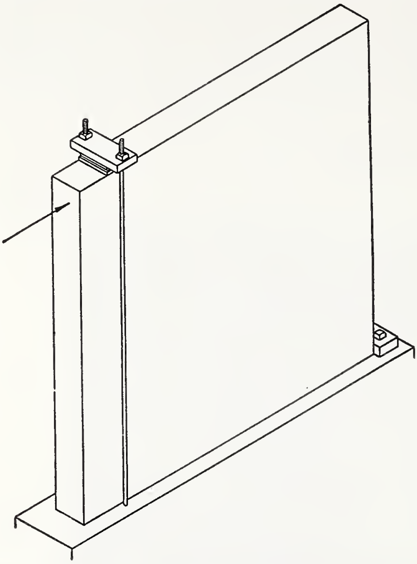
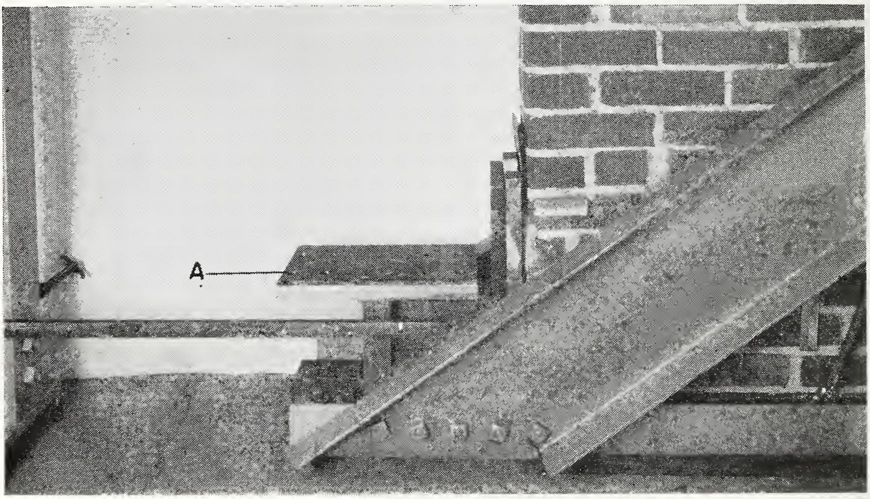


Fig. 21.—Racking Load on Specimen.



A—Stop.

Fig. 22.—End of Racking Frame.

(*b*) *Horizontal Deformation.*—Both mirror-scales of the deflectometer shall be read simultaneously before the load is applied to the specimen, then when the racking load has been applied, and again after the load has been released. When each set of readings of horizontal deformation is made, the corresponding readings for the horizontal wire shall be recorded.

Calculations and Report

40. (*a*) For each mirror-scale, the movement under each racking load shall be calculated as the difference between

the reading of the mirror-scale when the load is applied and the initial reading. For the vertical wire, the horizontal movement of the top of the specimen shall be calculated as the difference between the movements for the two mirror-scales multipled by the ratio: 8 ft. divided by the vertical distance between the mirror-scales. Using a similar method and the readings for the horizontal wire, the vertical movement of the specimen shall be calculated and subtracted from the horizontal movement to obtain the actual horizontal deformation and the set of the specimen in a vertical distance of 8 ft. for a given racking load. The maximum racking load shall be recorded, provided this load does not exceed 50,000 lb.

(*b*) The results shall be reported in the form of a graph in accordance with Section 61.

Method B. For Evaluation of Sheathing Materials on a Standard Wood Frame.

Scope

41. (*a*) This method of test measures the resistance of panels, having a standard wood frame, and sheathed with sheet materials such as structural insulating board, plywood, gypsum board, transite, etc., to a racking load such as would be imposed by winds blowing on a wall oriented at 90 deg to the panel. It is intended to provide a reliable, uniform procedure for determining the resistance to racking load provided by these sheet materials as commonly employed in building construction. Since a standard frame is employed, the relative performance of the sheathing is the test objective.

(*b*) This test is conducted with standardized framing, loading procedures, and method of measuring deflection, as detailed in the method to insure reproducibility. Provision is made for following the sheathing manufacturers' recommendations for attaching the sheathing to the frame, and for reporting the behavior of the specimen over its entire range of use.

(*c*) In applying the results, due allowance shall be made for any variation in construction details or test conditions from those in actual service.

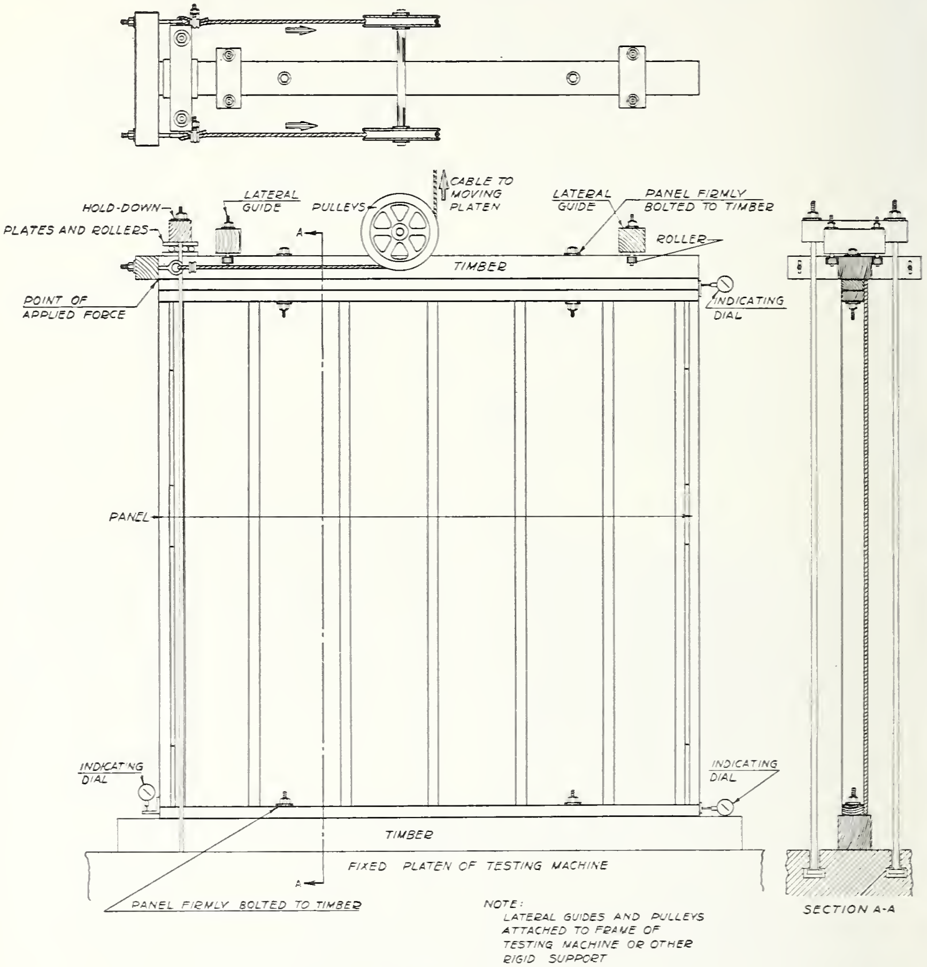
Apparatus

42. The apparatus may be of the type described in Section 37 or that shown in Fig. 23 which is specifically applicable to tests conducted in a testing machine. Load shall be measured by means of the testing machine, or a dynamometer attached to cables that load the specimen, or in linkage with a hydraulic jack used to apply load. The essential parts of the testing apparatus, exclusive of the testing machine or loading frame, are as follows:

(*a*) *Base and Attachment of Specimen to Lower Platen of Testing Machine or Frame.*—The test panel shall be attached to a timber or steel plate that is in turn attached rigidly to the base of the testing machine or loading frame. This member may be of any convenient cross-section, but it shall be at least as long as the panel. Means shall be provided to bolt or otherwise attach the sole plate of the panel firmly to this member. For illustrative purposes, two bolts are shown in Fig. 23. More may be used if required.

(*b*) *Hold-Down.*—A hold-down shall be provided as shown in Fig. 23 to overcome the tendency of one end of the panel to rise as the racking load is applied. Plates and rollers shall be provided between the test specimen and the hold-down so that the top of the specimen can deflect horizontally with respect to the bottom without unnecessary interference from the hold-down. Because the amount of tension in the rods of the hold-down may have an effect on the results of the test, nuts on the hold-down rods shall be tightened so that the total force in each rod does not exceed 20 lb at the beginning of test as determined by previous calibration.

(*c*) *Load-Applying Apparatus.*—Load shall be applied to the specimen through a 4 by 6-in. timber firmly bolted to the upper plates of the panel as shown in Fig. 23. Loading shall be a compressive force against the end of the timber attached to the upper plate. When a testing machine is used, pulleys and cables such as shown may be used to transmit the vertical movement of the tension head of the machine to the horizontal movement in the specimen.



NOTE:
LATERAL GUIDES AND PULLEYS ATTACHED TO FRAME OF TESTING MACHINE OR OTHER RIGID SUPPORT

Fig. 23.—Racking Load Assembly.

(*d*) *Lateral Guides.*—Lateral guides, such as are shown, shall be provided so that the specimen will deflect in a plane. The rollers should be bearing-supported to reduced friction to a minimum. The lateral guides shall be firmly attached to the frame of the testing machine or to a frame attached to its base. Plates for the rollers may be up to 12 in. in length as required.

(*e*) *Indicating Dials.*—Indicating dials, or scales and wires, shall be provided to measure the displacement of the different parts of the panel during test. The readings shall be accurate to the nearest 0.01 in. The locations of the dials shall be as shown in the lower left, lower right, and upper right corners of the side view of the test assembly in Fig. 23. The dial at the lower left, which is attached to the stud, measures any rotation of the panel, the dial at the lower right measures any slippage of the panel, and the dial at the upper right measures the total of the other two plus the deformation of the panel. Therefore the horizontal deflection of the panel at any load is the reading of the dial at the upper right less the sum of the readings of the other two.

NOTE.—Dial gages reading 0.001 in. and having total travel of 4 in. or more are available.

Test Specimens

43. (*a*) The test specimen shall be 8 by 8 ft and the framing shall be constructed as shown in Fig. 24, and a minimum of three panels of each construction shall be tested. It is the intent of this test procedure to evaluate the stiffening effect of the sheathing material, therefore the frame shall be constructed as nearly like the frames shown in Fig. 24 as possible. Frames shall be newly constructed for each test. All individual framing members shall be continuous. The moisture content of framing material shall be between 12 and 15 per cent when the panel is fabricated.

(*b*) The method of applying the sheathing shall be exactly as specified by the manufacturer. The spacing of nails shall be as recommended. Nails shall be driven through the sheathing into only the outside 2 by 4-in. timber of each corner post shown in Fig. 24. The importance of the nailing of sheathing to the framing cannot be overemphasized. Slight differences in edge clearances, angle of nail, and amounts of penetration of heads of nails into the sheathing have appreciable effects on the results of test. Unless otherwise specified, nails shall be driven perpendicular to the surface of the sheathing with the center of each nail the specified distance from the edge of the sheathing. Nails shall be driven so that the head of the nail contacts the surface of the sheathing but not so deep as to crush the surface.

Procedure

44. (*a*) *Loading.*—The load shall be applied continuously throughout test at a uniform rate of motion of the movable platen of the testing machine or other loading device used. The recommended speed of testing shall be such that the loading to 800 lb total load shall be completed in not less than 2 min from the start of test (Note 1). The loading to 1600 and 2400 lb total load and to failure shall employ the same rate of travel of the platen of loading device as for the loading to 800 lb. The speed of testing used shall be given in the report of test.

NOTE 1.—It is not possible to present a single testing speed because of the variations in the relative rigidity of the various types of panels that can be used.

(*b*) *Loading Procedure.*—The specimen shall be loaded in three stages to 800, 1600, and 2400 lb total load at a uniform rate (Note 2). After the load of 800 lb is placed on the specimen, all of the load shall be removed and any residual deflection (set) in the panel noted. The specimen shall than be loaded to 1600 lb and the load again removed and any additional set noted; after which the loading shall be increased to 2400 lb and the load again removed and the set again noted. Load shall be applied continuously for each of the increment loads specified above and load-deflection data obtained. These data should be obtained for at least each 200 lb of loading. Deflections should be obtained during the loading cycle, and if desired during the unloading cycle as well.

After the specimen is loaded as specified to 800, 1600, and 2400 lb, it shall be loaded again to failure or until the total deflection of the panel becomes 4 in. (Note 3). Readings of deflection should be obtained for the same intervals of load as were used for the other loadings.

NOTE 2.—To provide data to meet performance requirements, other values of total load may be included in the test procedure. The same rate of loading should be used as for the loadings specified and the report shall indicate additional loadings evaluated and the results obtained.

NOTE 3.—Some constructions will continue to deflect under increasing load with no apparent maximum load, but the deflections will become so great that any data obtained from extending the test would be of little importance.

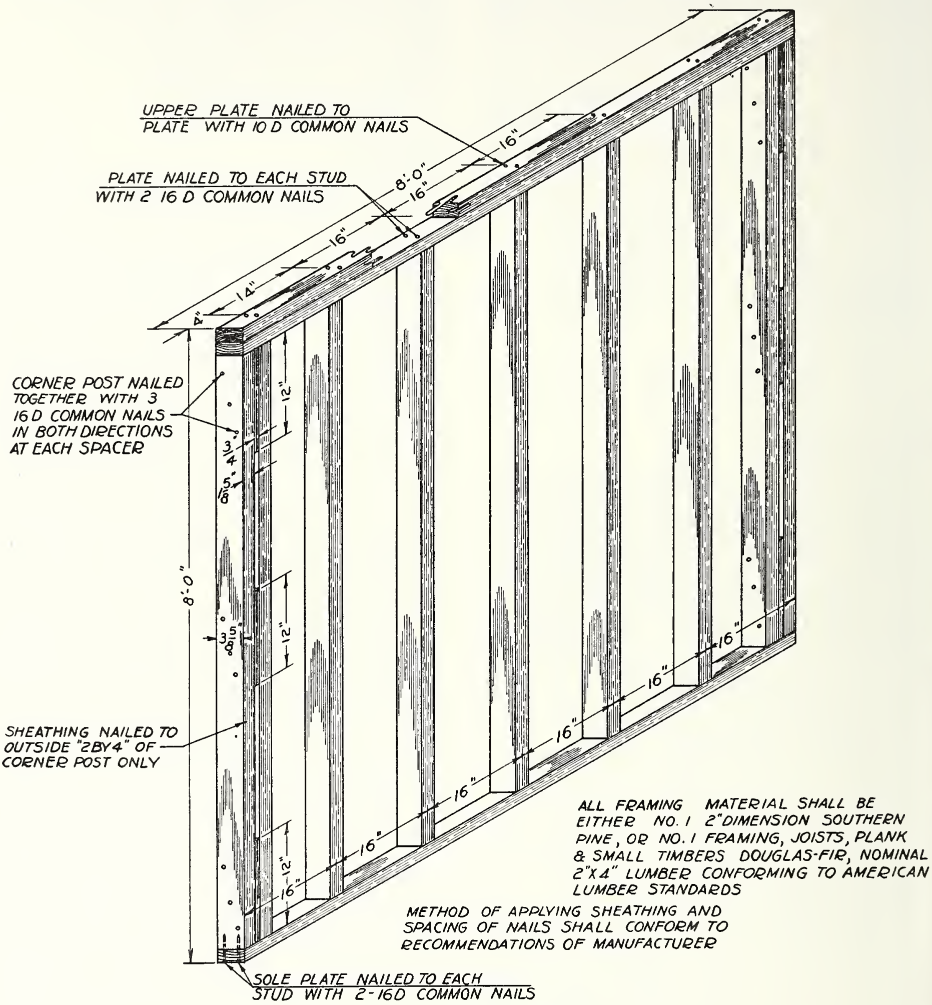

UPPER PLATE NAILED TO PLATE WITH 10 D COMMON NAILS
PLATE NAILED TO EACH STUD WITH 2 16 D COMMON NAILS
8'-0"
16"
16"
16"
14"
4"
CORNER POST NAILED TOGETHER WITH 3 16 D COMMON NAILS IN BOTH DIRECTIONS AT EACH SPACER
12"
3/4"
5/8"
8'-0"
3 5/8"
12"
SHEATHING NAILED TO OUTSIDE "2BY4" OF CORNER POST ONLY
12"
16"
16"
16"
16"
16"
16"
ALL FRAMING MATERIAL SHALL BE EITHER NO. 1 2" DIMENSION SOUTHERN PINE, OR NO. 1 FRAMING, JOISTS, PLANK & SMALL TIMBERS DOUGLAS-FIR, NOMINAL 2"X4" LUMBER CONFORMING TO AMERICAN LUMBER STANDARDS
METHOD OF APPLYING SHEATHING AND SPACING OF NAILS SHALL CONFORM TO RECOMMENDATIONS OF MANUFACTURER
SOLE PLATE NAILED TO EACH STUD WITH 2-16D COMMON NAILS

FIG. 24.—Test Panel Specimen.

Calculation and Report

45. (*a*) For each dial, or other measuring device, the movement under each racking load shall be calculated as the difference between the readings when load is applied and the initial readings at the start of the test. Set readings shall be calculated as the difference be-

tween the readings when the load is removed and the initial readings.

(*b*) The report shall indicate the deflections at 800, 1600, and 2400 lb and the set after loading to these amounts. Load-deflection curves obtained during loading to failure and to 800, 1600, and 2400 lb shall be presented in the form of a graph as prescribed in Section 61. Maximum load and any observations on the behavior of the panel during test and at failure shall be included. Residual deflections (sets) shall be expressed as percentages of the deflections that produced the sets as well as in inches. If the specimen fails, the visible failure shall be described. If the specimen has been subjected to any special conditioning prior to test this treatment shall be described in detail. The report shall describe the sheathing used, the method of applying the sheathing, the type and spacing of nails, and the method and rate of loading employed.

TESTS OF PARTITIONS, LOAD-BEARING

General Requirements

46. (*a*) The apparatus, test specimens (see Section 3), and procedures for tests of partitions, load-bearing, shall be the same as those for walls (Sections 7 to 40), except that there shall be no tensile load tests on partitions (Note 1).

Note 1.—Under service conditions, the floor above cannot exert a tensile load on a partition.

(*b*) Provided the partition is symmetrical about a plane midway between the faces, the transverse, concentrated, and impact loads shall be applied to one face only (Note 2); therefore, for these tests, there shall be three duplicate specimens, not six as for walls, and the load may be applied to either face.

Note 2.—If the partition is symmetrical about a plane midway between the faces, the results for loads applied to one face of a specimen should be identical with those obtained by applying loads to the other face.

TESTS OF PARTITIONS, NON-LOAD-BEARING

Impact Load

Test Specimens

47. (*a*) Tests shall be made on six duplicate specimens, each having a height of 8 ft. and a nominal width of 4 ft. (see Section 3).

(*b*) Provided the partition is symmetrical about a plane midway between the faces, the impact loads shall be applied to one face only (see Note 2, Section 46); therefore, for this test, there shall be three duplicate specimens, not six as for walls, and the load may be applied to either face.

Procedure

48. The tests shall be conducted in accordance with Sections 30 to 36 on impact tests for walls.

Concentrated Load

Test Specimens

49. Tests shall be made on each of the impact specimens after the impact tests are completed, the load being applied to the same face of the specimen.

Procedure

50. The test shall be conducted in accordance with Sections 22 to 29 on concentrated load tests of walls.

TESTS OF FLOORS

TRANSVERSE LOAD

Test Specimens

51. Tests shall be made on three duplicate specimens, each having a length of 12 ft. 6 in. and a nominal width of 4 ft. (see Section 3).

NOTE.—In a small house, the length of a floor between supports and parallel to the joists is about 12 ft. The specimens are 6 in. longer than the span so that each end extends 3 in. beyond the support. A span of 12 ft. has been chosen for floor specimens because for shorter spans in the floor of a house the construction usually is identical with that for spans of 12 ft. The strength for spans slightly greater than 12 ft. can be estimated with sufficient accuracy for practical purposes by the usual engineering methods, if the behavior of 12-ft. span floor systems is known.

Procedure

52. (*a*) The test shall be conducted in accordance with Sections 15 to 18 on transverse load tests of walls, except that the span shall be 12 ft. and the loads shall be applied only to the upper (finish floor) face of the specimen. If practicable, floor specimens shall be tested in the horizontal position. If tested in the vertical position, the test shall be conducted in accordance with Sections 19 to 21 on transverse load tests on walls in the vertical position. If tested in the vertical position, transverse load equal to the weight of the specimen shall be deducted from each recorded load to obtain the applied load on the specimen.

(*b*) *Strength on Short Span.*—The transverse strength of any floor construction increases as the span is shortened. If the strength of the construction for a shorter span is desired, it shall not be computed, but the construction shall be tested on the shorter span.

CONCENTRATED LOAD

Test Specimens

53. Tests shall be made on each of the transverse specimens after the transverse tests are completed.

Procedure

54. The test shall be conducted in accordance with Sections 22 to 29 on concentrated load tests of walls, except that the loads shall be applied only to the upper (finish floor) face of the specimen.

IMPACT LOAD

Test Specimens

55. Tests shall be made on three duplicate specimens, each having a length of 12 ft. 6 in. and a nominal width of 4 ft. The specimens for impact load tests shall be of the same "construction" as the specimens for transverse load tests (see Section 2 (*c*)).

Procedure

56. The test shall be conducted in accordance with Sections 30 to 33 on impact load tests of walls, except that the span shall be 12 ft. and the impact loads shall be applied only to the upper (finish floor) face of the specimen.

TESTS OF ROOFS

TRANSVERSE LOAD

Test Specimens

57. Tests shall be made on three duplicate specimens, each having a length of 14 ft. 6 in. and a nominal width of 4 ft. (see Section 3).

NOTE.—In a small house, if the supports for the roof are vertically above those for the floor and the horizontal distance between the supports is 12 ft. (floor span), the roof span is also 12 ft. if the roof is flat. If the roof slopes at an angle of 30 deg. with the horizontal, the distance between roof supports measured along the roof is about 14 ft. A roof span of 14 ft.

was, therefore, chosen for the roof specimen because for shorter spans in the roof of a house the construction usually is identical with that for spans of 14 ft. The specimens are 6 in. longer than the span so that each end extends 3 in. beyond the support. For roof constructions, the strength for spans greater than 14 ft. can be estimated with sufficient accuracy for practical purposes by the usual engineering methods, if the strength is known for a 14-ft. span.

Procedure

58. (*a*) The test shall be conducted in accordance with Sections 15 to 18 on transverse load tests of walls, except that the span shall be 14 ft. and the loads shall be applied only to the upper (weatherproofed) face of the specimen. The transverse strength of a roof construction under loads acting outward may appear to be less than the strength under loads acting inward. For such constructions, loads acting outward should be applied to specimens.

(*b*) *Strength on Short Span.*—The transverse strength of any roof construction increases as the span decreases. If the strength of the construction for a shorter span is desired, it shall not be computed, but the construction shall be tested on the shorter span.

CONCENTRATED LOAD

Test Specimens

59. Tests shall be made on each of the transverse specimens after the transverse tests are completed.

Procedure

60. The test shall be conducted in accordance with Sections 22 to 29 on concentrated load tests of walls, except that the loads shall be applied only to the upper (weatherproofed) face of the specimen.

REPORTS

Reports

61. The results of each of the tests shall be shown graphically, as illustrated in Fig. 25. Loads shall be plotted as ordinates and the deformations as abscissas for all tests. There are at least three specimens for each test and the results for each test shall be shown on the same graph. Although the particular specimen for each point on the graph is not designated, they shall be recorded on the laboratory data sheets. The points for deformation under load shall be shown by open circles and those for set by solid circles. The three values for either the deformation or the set shall be averaged and this average value plotted in pencil on the graph. A smooth curve shall be drawn among the average points to show the average behavior of the construction. The load-deformation curves shall be continuous lines and the load-set curves shall be

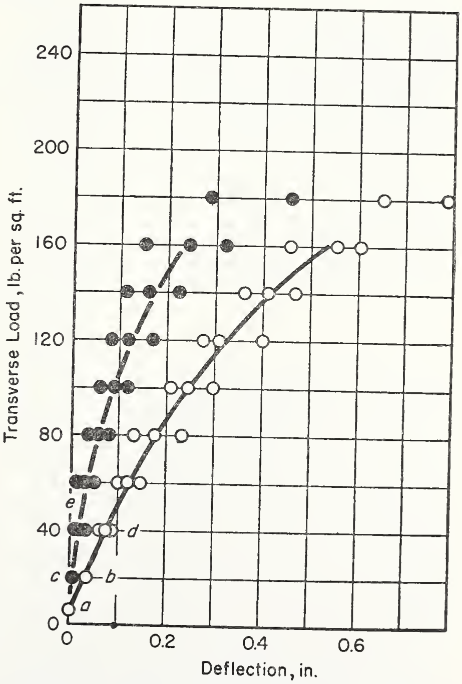


FIG. 25.—Typical Graph Showing Results.

28-80

dashed lines. If readings are obtained under greater loads for some specimens than for others, all the values shall be plotted, but the curves shall be drawn only to the average values for which there are three values.

APPENDIX

Evaluation of Test Results

The method of test, involving the application of the loads in increments and the concurrent measurement of deformation and set, simulates, to some extent, the conditions of repeated loading under service conditions. Therefore, results by such a method of loading may be more useful than those obtained by increasing the load continuously throughout the test. The data from increment loading tests may show whether different portions of a construction act as a unit under load, whether the fastenings or bonds have adequate strength, or whether they rupture under repeated loads. For any engineering structure, including small houses, it is necessary not only that the strength be adequate, but also that the deformation under load shall not appreciably decrease the usefulness of the structure. If the working load and the allowable deformation for an element for a house are known, constructions complying with these requirements may be selected by inspection of the graphs from tests of such constructions.

A structure is elastic if, after a load has been applied and then removed, the set is inappreciable. If the set is small for an element of a house it may be assumed that the construction has neither been damaged nor appreciably deformed by the load. The set, therefore, is another property that may be used when comparing different constructions and may be useful when selecting a construction for a particular purpose.

Obviously, the differences between the points and the curve are a measure of the variations in the properties of the construction.

The variations in the properties of a construction as used commercially for houses, in all probability, will be greater than the variations for the three specimens tested as directed in these methods because these specimens will be all fabricated at the same time by the same workmen and from the same lot of material.

Building codes and specifications for house construction might logically be based on performance requirements, when the basis for such requirements is known.

Standard Methods of

TESTING TRUSS ASSEMBLIES[1]

ASTM Designation: E 73 - 52

Adopted, 1952.[2]

This Standard of the American Society for Testing Materials is issued under the fixed designation E 73; the final number indicates the year of original adoption as standard or, in the case of revision, the year of last revision.

Scope

1. These methods of testing building truss assemblies under actual or simulated service conditions are provided for the determination of the strength and stiffness of the structures, and also of the adequacy of materials, design, connections, and fabrication.

Types of Tests

2. A truss test may be either a proof test or a test to failure. Proof tests are frequently made simply to provide assurance that the truss will support a specified load or to determine the deflection under a specified load. If the truss is not damaged by the proof test, it may be placed or kept in service. In testing to failure, more detailed information is generally desired such as load capacity, deflection, adequacy of connections, and factor of safety. If desired, either type of test may be extended to include a determination of the magnitude and distribution of the stresses in the members and connections to permit more comprehensive analysis.

Number of Tests

3. The number of like trusses that should be tested will vary with the desired accuracy and reliability of the information to be obtained and with the purpose of the test. Where only rough or approximate values are desired, a single test may suffice. Ordinarily, where more accurate and reliable values are required, a minimum of three tests is preferred.

Loading

4. (*a*) While these methods are best suited to tests of trusses before installation in the building, they can also be applied to testing trusses after installation. In the former case, the truss may be tested in either a vertical position (normal or inverted) or in a horizontal position. Additional increment loadings must be applied to trusses tested in an inverted or horizontal position to offset the effect of the dead load of the trusses in these abnormal positions.

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[1] Under the standardization procedure of the Society, these methods are under the jurisdiction of the A.S.T.M Committee E-6 on Methods of Testing Building Constructions.

[2] Prior to adoption as standard, these methods were published as tentative from 1948 to 1952, being revised in 1952.

(*b*) Vertical loads may be applied in the form of dead weight through bearing, suspension, or jacking arrangements. Horizontal loads normally are applied by a jacking arrangement or, if by dead weight, through the use of cables and pulleys.

(*c*) Loads applied by hydraulic jacks may be measured with fair accuracy by use of hydraulic gages; the jack and gage assembly should be calibrated at different positions of the piston and the jacks should be free from leakage to insure a constant load during an observation. Screw jacks used in combination with spring dynamometers of the proving ring type are capable of providing a high accuracy in load maintenance and determination.

(*d*) Uplift forces such as wind loads may be simulated by reversing the direction of the applied gravity test load by means of pulleys, by the use of jacks, or by testing the truss upside down. The method first mentioned is preferable because in that case the action of dead weight more closely represents actual service conditions.

(*e*) Sand bags, masonry units, billets, pig lead or iron, etc., used for uniformly loading the truss, if required in several layers shall be placed in individual piles so separated from each other that arch action cannot occur as the truss deflects.

(*f*) All details of load arrangements shall be such as to result in the desired truss loading, whether concentrated or distributed loads are applied. Furthermore, the distribution of the loads during application of each increment of loading shall approximate as closely as feasible the intended overall load distribution. Care shall be taken to avoid eccentricity of loading, unless eccentric loading is desired.

Measurements

5. (*a*) A complete set of deflection and other measurements at each increment of load is desirable to permit detailed analysis of the test results. Deflection readings may be determined in a number of ways, one of the simplest methods being by means of a taut wire placed lengthwise beneath the lower chord of the truss and attached to the truss at the ends. Readings are taken on a scale and mirror attached to the truss at the deflection points. The scale is read by lining up the taut wire with its reflection in the mirror. Other common methods of measuring deflection involve the use of micrometer dials attached to a suitable support and bearing at the desired points on the lower chord, or the use of a surveyors level, reading on targets attached to the truss. In all cases, if there is any settlement of the end supports, the method should compensate for this end movement.

(*b*) When desired, strain measurements may be taken in a number of ways, using extensometers or fixed gages such as the Huggenberger, graphic, and electrical resistance gages, or portable strain gages of the Berry or Whittemore type. With all types of gages, the measurements should be made by an operator experienced in the techniques peculiar to the instrument used.

Procedure for Trusses Tested in Normal Position

6. The following procedure shall be employed in the usual case wherein the truss is tested in its normal position (Fig. 1) with the axial plane vertical.

(*a*) Foundations shall be provided under supports that are capable of carrying the end reactions of the truss without appreciable settlement or lateral movement. Supports shall be high enough to permit the suspension of the test loads from the loaded chord with an ample allowance for the truss deflection.

(*b*) The compression chord of the truss shall be braced to prevent lateral movement, but the bracing shall not affect the free vertical deflection of the truss under load. This bracing, in so far as possible, shall duplicate the lateral support provided in the structure; for example, if roof purlins brace the truss at panel points, the lateral test bracing shall be placed at the panel points of the top chord.

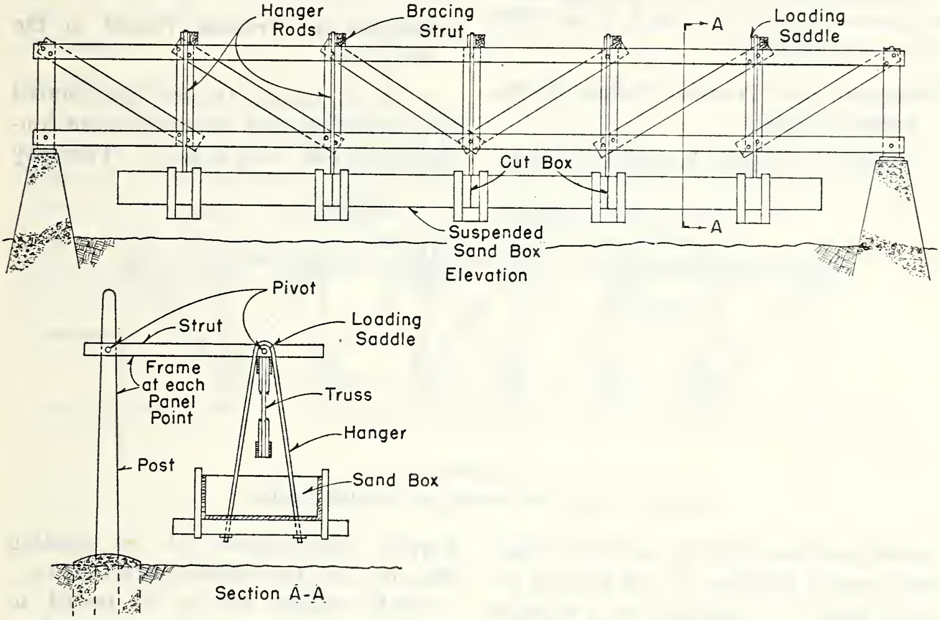

FIG. 1.—Truss Set Vertical, in Normal Position.

(*c*) Load shall be applied to the truss in increments in a manner simulating service conditions (concentrated at purlins or uniformly distributed) and loads, deflections, and other data desired at each increment of loading shall be recorded. Failures or other signs of distress in members and joints shall be noted and recorded.

(*d*) Each increment of load shall be applied at as nearly a uniform rate as possible. After placing an increment of load on the truss, sufficient time, preferably about 5 min., shall be allowed for the truss to come to substantial rest before taking deflection readings. At the design loading, or at such other stage of the test as may be desired, the load should be allowed to remain on the truss for a period of at least 24 hr. to determine whether additional deflection takes place. In some cases, it may be desirable to unload the truss after applications of increments of load, to determine the recovery and set, or to plot a curve showing the set. In all cases where the truss is tested to failure, the ultimate load shall be recorded.

(*e*) Although the load increments may vary with circumstances, a satisfactory deflection or strain curve can usually be obtained if each of the first four increments are 25 per cent of the total live and dead load design loading and all additional increments are 50 per cent of the live load design loading.

(*f*) A satisfactory method of loading is by suspending a sand box under the truss by means of hangers which bear on the truss at points simulating actual service conditions. The box should be divided into independent sections, preferably by being cut at each hanger support to avoid a continuity which may create an indeterminate, unbalanced loading at the various supports. The load shall be so distributed in the boxes to provide the desired loads at the points of suspension. All auxiliary apparatus supported by the truss shall be recorded as an applied load.

Procedure for Trusses Tested in Inverted Position

7. When the truss is tested in an inverted position (Fig. 2), anchors to take the upward reactions at the ends of the truss shall be attached to a suitable foundation or test base. Calibrated jacks shall be set under the inverted top chord of the truss and loads applied at panel points or otherwise as required to simulate service conditions. Increment loads, deflections, strain gage readings, and observations at the connections shall be recorded as described in Section 6. Both tension and compression chords shall be braced to simulate the lateral support provided in actual service and the bracing shall be applied to the ends of the truss as well as to the intermediate points. The bracing shall be of the same general character as that described in Section 6.

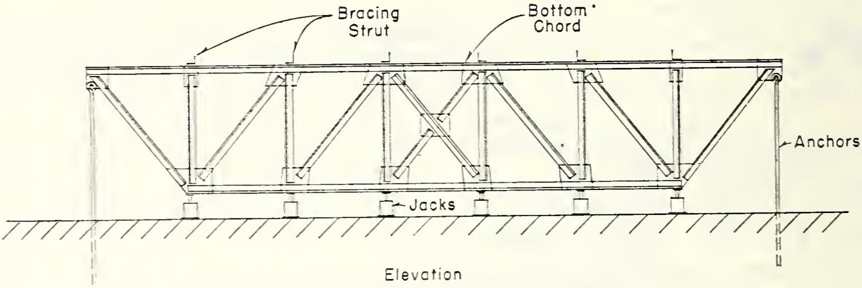

FIG. 2.—Truss Set Vertical, in Inverted Position.

Procedure for Trusses Tested in a Horizontal Position

8. When the truss is tested in a horizontal position, an auxiliary frame or truss arrangement is required to take the reactions from the test truss and calibrated loading jacks. Otherwise the testing procedure shall conform essentially to that described in Section 6.

Procedure for Trusses Tested in the Structure

9. (*a*) In testing trusses incorporated in a structure, it is normally more convenient to test them in pairs. This may require reinforcement of the existing deck to carry the additional test loads.

(*b*) If trusses are to be tested to destruction, all connections resulting in a load distribution to the rest of the structure (except for lateral bracing and end supports of truss) shall be severed. Where a limited test loading is applied to a truss that will continue in service, the conditions of independent truss action shall be approximated as closely as is practicable.

(*c*) Loading may be accomplished by placing sand bags, metal billets, or masonry blocks on the roof deck, floor, or auxiliary platform, or by placing water in tanks on top of the truss or suspended from the truss, as prescribed in Section 6.

(*d*) Where loading is to be reversed to simulate wind uplift, struts or jacks operating against the underside of the top chord of the truss may be used to apply the load. Where ceilings are in place, uplift may be applied by jacking up the lower chord of the trusses.

(*e*) Although this method describes testing of trusses only, auxiliary tests to determine adequacy of roof decks and their fastenings in resisting downward and upward loads may be desired. Otherwise the test procedure shall conform essentially to that described in Section 6.

Auxiliary Tests

10. To aid in the interpretation of the results of a truss test, it is generally desirable to determine the quality of the material, fastenings, or both, used in the truss. Such determinations should be made in accordance with the pertinent A.S.T.M. methods.

Report

11. The report shall include the following:

(*1*) A statement that the test or tests were conducted in accordance with these methods. If deviations from these methods are made, they shall be described in the report.

(*2*) Description of the truss or trusses tested, preferably with sketches.

(*3*) A detailed description, preferably with sketches, of the test setup, auxiliary apparatus, and equipment.

(*4*) A detailed description of the method of loading, method of making measurements, and testing procedure.

(*5*) All data, preferably with graphs. This should include pertinent observations on the behavior of the truss or trusses during the test.

(*6*) Analysis and calculations.

(*7*) Conclusions.

Recommended Practice for

LABORATORY MEASUREMENT OF AIRBORNE-SOUND TRANSMISSION LOSS OF BUILDING FLOORS AND WALLS[1]

ASTM Designation: E 90-55

ADOPTED, 1955.[2]

This Recommended Practice of the American Society for Testing Materials is issued under the fixed designation E 90; the final number indicates the year of original adoption or, in the case of revision, the year of last revision.

Scope

1. (*a*) This recommended practice is intended to cover the random incidence or reverberant sound method for laboratory measurement of airborne-sound transmission loss of large-scale building floors and walls and other elements of building construction such as doors, windows, etc. While generally applicable to large specimens such as building constructions, this recommended practice is also applicable to smaller specimens such as airplane panels (Note).

NOTE.—For such smaller specimens there is also available the normal incidence or tube method, first developed by a Harvard-Massachusetts Institute of Technology group for measuring specimens of the order of 1.5 by 1.5 ft. in size. In certain cases it may be of advantage to use this small-scale, close-coupled method for testing building constructions.

(*b*) This recommended practice covers only measurements of airborne-sound transmission loss, where airborne-sound refers to those sounds which originate within a room, are carried through the air, and then are transmitted through the test specimen as a result of the sound field excitation. It is not applicable to measuring the sound insulation of a test specimen for impact or tapping sounds such as are caused by direct mechanical contact with the specimen.

Theory

2. (*a*) In the reverberant sound field method (**1, 2, 3**)[3] of determining the sound insulation rating of a building wall or floor, the panel to be tested is inserted in an opening between two rooms in one of which a source of sound is located. The difference in sound level between the source and receiving rooms may be related to give the efficiency of the construction in

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[1] Under the standardization procedure of the Society, this recommended practice is under the jurisdiction of the ASTM Committee E-6 on Methods of Testing Building Constructions.

[2] Prior to adoption, this recommended practice was published as tentative from 1950 to 1955.

[3] The boldface numbers in parentheses refer to the references listed at the end of this recommended practice.

terms of the transmission loss in decibels, which is defined as follows:

$$TL = L_1 - L_2 + 10 \log_{10} \frac{S}{A_2} \ldots\ldots (1)$$

where:

TL = transmission loss,

L_1 = average sound level in decibels in room 1, the source room,

L_2 = average sound level in decibels in room 2, the receiving room,

S = total area of sound transmitting surface, and

A_2 = total absorption in room 2, A_2 being measured in the same units as S.

(*b*) The theoretical basis of the definition of transmission loss as given in Eq. 1 was first developed by Buckingham (3). In his treatment it is assumed that a reverberant sound field exists in both the source and receiving rooms. An ideal reverberant sound field may be characterized by the existence of a constant sound energy density at any point in the field and also by the condition that any small element of volume may be considered as a nondirectional source of energy, that is, it radiates sound energy uniformly in all directions. It will be readily seen that a reverberant sound field of necessity requires that the individual wave packets of sound energy striking the panel face have random angles of incidence.

(*c*) Another more subtle assumption inherent in the derivation is that the test specimen shall be large enough to preclude the possibility that the method of supporting or of clamping the boundaries of the test specimen will affect the transmission loss measurements. In general, this means that the mode of vibration of the test specimen under the influence of the sound field must be such that any small region of the specimen vibrates independently of adjacent areas, the amplitude of vibration of the given area depending only on the sound field existing in its immediate neighborhood. Schoch (4) has shown that in the case of a plate this will occur only for test frequencies which are considerably greater than the lowest natural frequency of the plate.

The detailed recommendations in the following Sections 3 to 9 are designed to comply with these theoretical requirements.

Test Rooms

3. (*a*) *Size.*—The physical dimensions of the test rooms shall be such that the frequency of the lowest normal mode of vibration of the test rooms is below that of the lowest test frequency.

(*b*) *Construction.*—The walls and construction of the test rooms shall be such as to be a more efficient sound insulating structure than any specimen that might have to be tested. In general, this requires that the total amount of sound energy transmitted into the receiving room by surfaces other than that of the test specimen be at least 10 db below the amount of energy transmitted by the test specimen.

NOTE.—The extent to which the above conditions are met can be ascertained by either of the following methods:

(*a*) Close off the test opening with a panel identical in construction to the test room wall. Measure the sound transmission loss corresponding to this construction. From this, the maximum observable transmission loss which may be measured with any test specimen may be calculated.

(*b*) Measure the average vibration amplitude of the test specimen and the average vibration amplitude of the test rooms walls. Assuming, as an approximation, plane wave emission of sound, compare the amount of sound emitted by the specimen with that emitted by all the walls of the test room.

(*c*) *Acoustic Treatment.*—The walls of either or both test rooms may be left bare so that they are highly reflective, acoustically speaking, or acoustical absorption may be applied to the walls. In the latter case, special considerations relative to placement of the microphones will be required (3) and equations different from Eq. 1 will be needed for calculation of the transmission loss (see Section 7(*b*)).

Test Specimens

4. (*a*) *Size and Mounting.*—The test specimen which is to typify a wall or floor shall be large enough to include all of the essential constructional elements. The smallest dimension (excluding thickness) shall be not less than 5 ft. In the case of doors, windows, and other smaller building elements, the test specimens shall be their customary size and shall be installed in a manner compatible with their installation in an actual building construction. An acoustically tight seal shall be provided between the test specimen and test opening.

(*b*) *Drying.*—Test specimens having plastered surfaces, or masonry walls requiring the use of cement or plaster, shall not be tested until they have had an adequate drying-out period. A minimum drying period of 30 days is recommended.

Test Frequencies

5. (*a*) *Number and Spacing.*—Measurement of transmission loss shall be made at a minimum of nine test frequencies. A total frequency range of 100 to 4000 cycles per sec. shall be covered. The nine frequencies shall be within ± 10 per cent of the following values: 125, 190, 250, 375, 500, 750, 1000, 2000, and 4000 cycles per sec. If so desired, additional test frequencies may be utilized.

(*b*) *Warbling.*—The test frequencies shall be warbled or otherwise modulated so as to produce a band of frequencies about the center of the band. The amount of warble will depend on the size of the test rooms and hence should be chosen so as to give satisfactory results for the test rooms in question.

(*c*) *Continuous Frequency Measurements.*—Paragraphs (*a*) and (*b*) are not to be interpreted as precluding the possibility of taking measurements by a continuously varying frequency which sweeps through the entire range of 100 to 4000 cycles per sec.

Loudspeakers

6. One or more suitable loudspeakers may be used in conducting the tests. To improve the uniformity of distribution of sound energy density in the source room, the loudspeakers may be stationed at different locations in the source room or they may be rotated or otherwise kept in motion.

Microphones

7. (*a*) *Number.*—One or more microphones may be used to determine the average sound level in the test rooms. If a limited number is used, they should be moved to several different positions in order to obtain the average sound level existing in the test rooms. If a large number of microphones are used at different stations in the rooms, their outputs may be combined either by switching rapidly between microphones or by placing the microphones in series—parallel combinations. A minimum of two different sets of observations, in which the source room microphones are interchanged with the receiving room microphones, should be taken. Averaging these two sets of measurements will eliminate systematic errors resulting from differences in response between the microphones. Alternatively, the testing laboratory may make cor-

rections for the different responses of microphones or amplifiers, or both, by an accurate calibration of them. The calibration should be carried out in such a way as to eliminate errors caused by variations in response between microphones or amplifiers, or both, when used to measure sound levels in reverberant sound fields.

(*b*) *Location.*—The positions in the source and receiving rooms at which microphones are to be located in order to determine the average sound level depend essentially on the acoustical treatment of the test rooms. The following possibilities may arise:

(*1*) If the rooms are left bare, the walls being highly reflective, a reverberant sound field will be present in the source room. Sound level readings in the source room should not be taken at positions less than 3 ft. from the specimen face. It will be found that the sound level at the specimen face on the receiving side is greater there than at any other location in the receiving room (3). As the microphones are moved away from the panel face in the receiving room the sound level decreases until it reaches a constant value which is maintained approximately over a large region in the receiving room. Measurements of average sound level should be confined to this region of the room. Ordinarily this requires that the distance of the microphones from the specimen face be not less than 3 ft. Equation 1 applies if the above precautions are taken.

(*2*) If it is desired to take sound level measurements at the panel face on the source side, the transmission loss is defined as follows (3):

$$TL = L_{10} - L_2 + 10 \log_{10} \frac{S}{A_2} - 3 \ldots .(2)$$

where L_{10} is the average sound level in decibels at the panel face in room 1, the other quantities being identical to those appearing in Eq. 1. In applying Eq. 2 it is necessary that the sound level measurements be made with a nondirectional sound pressure microphone and it is assumed that the face of the panel is highly reflective.

(*3*) In the event that the receiving room is acoustically dead, that is, all of the energy which is emitted by the specimen is completely absorbed by the receiving room so that none of it returns to the specimen face in the receiving room, the measurements in the receiving room may be made at the panel face. In this event, the transmission loss in decibels is defined as follows:

$$TL = L_1 - L_{20} - 3 \ldots\ldots\ldots\ldots (3)$$

where L_{20} is the average sound level in decibels at the panel face in the receiving room as measured by a sound-pressure microphone and L_1 is as defined in Eq. 1. If the measurements are made other than at the panel face in the dead room the data will have to be extrapolated to give L_{20}, so as to make Eq. 3 applicable.

(*4*) In the general case where the receiving room is not completely dead but only partially so, and it is desired to make measurements at the panel face in the receiving room, the transmission loss equations given on page 428 of the paper by London (3) may be used. In addition, this paper describes a method of determining the correction term 10 $\log_{10} S/A_2$ without making reverberation time measurements.

Number and Precision of Measurements

8. (*a*) A sufficient number of transmission loss measurements shall be taken to reduce the average deviation from the mean of dual sets of measurements to less than 1 db where the

transmission loss for a dual set of measurements is defined as the average of two sets of transmission loss measurements obtained by interchanging microphones initially in the source room with those in the receiving room. The transmission loss for a dual set eliminates systematic errors resulting from different microphone responses.

(*b*) Alternatively, if calibrated microphones or amplifiers, or both, are used as discussed in Section 7(*a*), a sufficient number of measurements shall be taken to reduce the average deviation from the mean of individual measurements to less than 1 db.

Transmission Loss for Low-Loss Specimens

9. In the event that the observed differences in sound level between source and receiving rooms are less than 15 db, sound energy will feed back into the source room to a significant extent, thus requiring modification of Eq. 1, which neglects this possibility. In this case the transmission loss is defined as follows:

$$TL = 10 \log_{10} \left[\text{antilog}_{10} \left(\frac{L_1 - L_2}{10} \right) - 1 \right] + 10 \log_{10} \frac{S}{A_2} \quad \ldots (4)$$

In the case of a dead receiving room Eq. 3 is still applicable, since no feedback of energy should take place in this case.

Report

10. The report shall include the following.

(*1*) A statement that the tests were conducted in accordance with this ASTM Recommended Practice E 90. Any deviations from this recommended practice shall be listed in the report.

(*2*) Description of the test specimen, and all of the essential constructional elements. The composition of plaster mixes or other plastic masonry applications shall be stated; also surface finish and method of application.

(*3*) Test specimen size, including thickness; also the weight per square foot of surface.

(*4*) Test results, reported as the sound transmission loss at the different test frequencies. The transmission loss figures shall be reported to the nearest decibel. If desired, the average transmission loss, which is defined as the arithmetical average of the transmission losses at the individual test frequencies, may be stated, provided the individual test frequencies for which the average is given are clearly indicated.

(*5*) Amount of warble used in the test shall be stated in accordance with Section 5(*b*).

(*6*) Where possible, the report should state the accuracy of the measurement and its reproducibility on identical specimens and those built to the same specifications.

REFERENCES

(1) E. Buckingham, "Theory and Interpretation of Experiments on the Transmission of Sound Through Partition Walls," *Scientific Papers*, Nat. Bureau Standards, Vol. 20, p. 193 (1925), *S506*.

(2) V. L. Chrisler and W. F. Snyder, "Recent Sound-Transmission Measurements at the National Bureau of Standards," *Journal of Research*, Nat. Bureau Standards, Vol. 14, No. 6, June, 1935, p. 749. (*Research Paper RP800.*)

(3) Albert London, "Methods for Determining Sound Transmission Loss in the Field," *Journal of Research*, Nat. Bureau Standards, Vol. 26, No. 5, May, 1941, p. 419. (*Research Paper RP1388.*)

(4) A. Schoch, "On an Asymptotic Relation for Forced Vibrations of Plates at High Frequencies," *Akustische Zeitschrift*, Vol. 2, p. 113 (1937); also summary in English in the *Journal*, Acoustical Soc. America, Vol. 9, p. 168 (1937).

Fire Tests

APPROVED AS
AMERICAN STANDARD
BY THE AMERICAN STANDARDS ASSOCIATION
ASA NO.: A2.4–1956
UDC 699.81:651.11:620.1

Standard Method of Test for
COMBUSTIBLE PROPERTIES OF TREATED WOOD BY THE CRIB TEST[1]

ASTM Designation: E 160 - 50

(*Formerly Designated C 160*)

Adopted, 1946; Revised, 1950.[2]

Reapproved in 1958 Without Change.

This Standard of the American Society for Testing Materials is issued under the fixed designation E 160; the final number indicates the year of original adoption as standard or, in the case of revision, the year of last revision.

Scope

1. This method covers a crib-test procedure for fire tests for combustible properties of wood treated to reduce flammability. The test relates to properties of treated wood as such, rather than to the performance of a fabrication used as an element of construction. Performance under this test shall be as prescribed in requirements applicable to materials intended for specific uses.

Apparatus

2. The apparatus shall consist of the following:

(*a*) *Test Chamber.*—A test chamber which may be either a room free from noticeable drafts, or a fume hood. If a fume hood is used, the ventilation shall be such as to cause a minimum movement of air to remove the smoke or gases.

(*b*) *Wire Frame and Ring Stand.*—A wire frame (see Fig. 1) suitable for supporting the specimen stacked in the form of a crib, and a ring stand 6 in. in inside diameter. The wire frame shall consist of four vertical wires, with a clear spacing of 2 in. to form a cage with square sections, held in position at the top by transverse wires on each side, and provided with transverse wires near the bottom which serve as spacers and supports for the specimen. All wire used in the frame shall be steel wire $\frac{1}{8}$ in. in diameter and connections shall be made by welding. Dimensions of the wire frame and the manner in which it is supported on the ring stand shall be as shown in Fig. 1. The frame shall be vertical and the hooks at the ends of the supporting arms made so that the frame will automatically be centered for any placement, with a minimum clearance to permit removal from the ring. These hooks serve as a self-centering device.

(*c*) *Burner.*—A Meker burner with perforated grid 2 in. in diameter.

(*d*) *Flame Shield.*—A flame shield (Fig. 2) for calibrating and checking the burner flame. The shield shall consist of a cylindrical section, 8 in. in diameter and 12 in. in height, and a conical top with an opening $2\frac{3}{4}$ in. in diameter. A No. 18-gage chromel-alumel thermocouple shall be mounted with its junction $\frac{1}{2}$ in. over the center of the top opening of the shield, for calibration of the burner flame. The shield shall be made of No. 24-gage sheet iron and shall be supported so that when the burner is placed directly under the center of the shield, the distance from the top of the burner grid to the thermocouple is 17 in. (see Fig. 2).

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[1] Under the standardization procedure of the Society, this method is under the jurisdiction of the A.S.T.M. Committee E-5 on Fire Tests of Materials and Construction.

[2] Prior to adoption as standard, this method was published as tentative under the designation C 160 from 1941 to 1946, being revised in 1946.

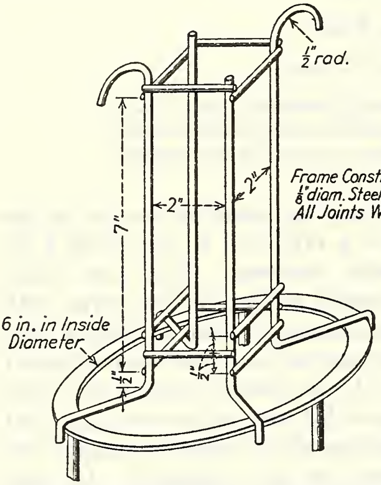

Fig. 1.—Wire Frame and Ring Stand for Supporting Crib Specimen.

(*e*) *Balance.*—A balance accurate at least to 0.1 g. and provided with a suitable scale pan.

(*f*) *Timer.*—A timing device recording minutes and seconds.

(*g*) *Oven.*—A thermostatically-controlled drying oven.

(*h*) *Meter.*—A potentiometer or millivoltmeter for indicating thermocouple emf. or temperature.

Sampling and Test Specimens for Wood Impregnated Throughout Entire Section

3. For interior trim or other lumber requiring penetration of treating solution throughout the section (but not for wood given incomplete penetration), the specimens shall be prepared as follows:

(*a*) One sample shall be taken from the lot for each 5000 bd. ft. or fraction thereof. Different species, and pieces of the same species with widely different thicknesses, shall be considered as separate lots and sampled accordingly. Each sample shall consist of a number of individual pieces selected so as to include material from different sections of a finished unit or different lengths of finished trim, or to include variations such as rate of growth, density, and other visible nonuniformities. Samples shall be cut not closer than 2 ft. from the ends of treated boards.

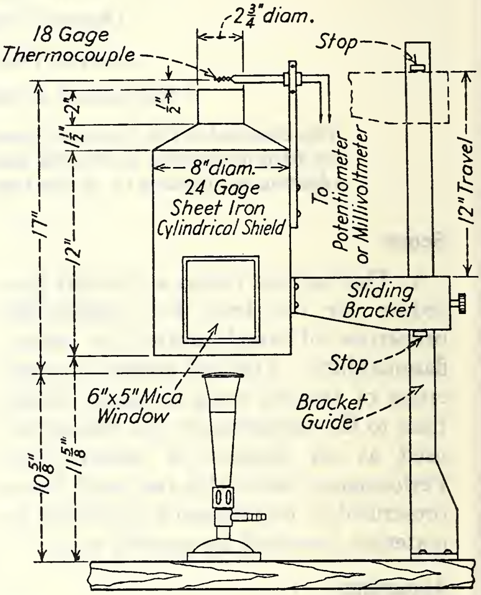

Fig. 2.—Flame Shield.

(*b*) The crib test specimen cut from the selected sample shall consist of 24 pieces $\frac{1}{2}$ by $\frac{1}{2}$ in. in cross-section and 3 in. in length, with surfaces smooth-sawed to dimensions within plus or minus $\frac{1}{32}$ in. The specimen shall be representative of the entire cross-section of the sample.

(*c*) For samples taken from boards having thicknesses ranging from ½ to 1⅛ in., the composite specimen shall be prepared by cutting parallel ½ by ½-in. pieces longitudinally from one or both faces across the full width of the board. For samples taken from trim of small sectional area, the specimen pieces will ordinarily be suitable as cut by any convenient sawing operation.

(*d*) For material of greater thickness, pieces shall be cut from one face and the center of the section, across the full width.

(*e*) When the material to be tested is less than ½ in. in thickness, the specimen pieces may be built up in laminated form with plies of approximately equal thickness. The plies shall be dressed smooth and assembled by nailing with ½-in. steel wire brads (No. 20 B.w.g., 0.035-in. nominal thickness) driven obliquely, spaced 1 in. apart, and symmetrically located on the 3-in. length. The laminated pieces should preferably be prepared in longer lengths and greater width to permit of cutting to the final specimen dimensions with smooth-sawed faces on the laminated edges. The weight of nails used shall be recorded for correction of the weight of specimen.

(*f*) A composite specimen prepared from more than one sample piece shall be taken so as to be representative of the average quality of the materials to be tested.

Sampling and Test Specimens for Incompletely Impregnated Wood

4. Where arrangements are made for sampling of each charge at the treating plant, the specimens of incompletely impregnated wood shall be obtained as follows:

(*a*) One sample piece furnished by the purchaser, previously agreed upon, selected, and identified shall be included for each 5000 bd. ft. in a charge, but no charge shall contain less than 4 nor more than 8 sample pieces. These sample pieces shall be of the same species of wood as the rest of the material in the charge and shall be fairly representative of the lot with respect to rate of growth, density, heartwood, and sapwood. They shall be identified by metal tags or the equivalent.

(*b*) Placement of sample pieces in the material to be treated on a tram shall be representative of the average exposure to the treating solution and yet be accessible for ready removal without seriously disturbing the loading.

(*c*) Sample pieces shall be at least 6 ft. in length and may be either full-size rough or dressed standard. They shall be of the same cross-sectional dimensions as the material in the lot for thicknesses up to and including 3 in. in nominal thickness. Where material in the charge is over 3 in. in thickness, irrespective of width, sample pieces shall be 4 by 4 in. in nominal size.

(*d*) One set of crib test specimens shall be cut from each selected sample piece and shall consist of 24 pieces ½ by ½ in. in cross-section and 3 in. in length, smooth-sawed to dimensions within plus or minus $\frac{1}{32}$ in. Not less than four similar pieces shall be cut for moisture test specimens. The specimens shall not be cut closer than 2 ft. from the ends of sample pieces nor closer than ½ in. from their edges. The specimens shall be cut so that one side will be from a treated face of the sample piece and shall be cut or chosen from locations fairly representative of density, heartwood, and sapwood for the piece as a whole.

Conditioning of Test Specimens

5. (*a*) The moisture content of the specimen when tested shall be 7 ± 3 per cent by weight of dry material. The moisture determination shall be made on a specimen approximately ¾ in. in thickness cut transversely at an intermediate

section of the sample, or on a moisture test specimen consisting of at least four additional ½ by ½ by 3-in. pieces of the prepared test specimen. The moisture test specimen shall be weighed to 0.1 g. or less and dried for 24 hr. at 212 ± 3 F. (100 ± 1.7 C.) The weight of the test specimen shall be recorded at the time of weighing the moisture test specimen. If the moisture content exceeds 10 per cent, the sample or prepared specimen shall be conditioned by drying at temperatures not exceeding 150 F. (65 C.) until the moisture content is within the prescribed limits. Low moisture content can be increased by storage in air on a screen over a pan of water. If not tested immediately, the specimen shall be stored, after conditioning, in such a manner as to prevent absorption or loss of water.

(*b*) The weight to which the sample must be conditioned to contain 7 per cent moisture shall be calculated as follows:

$$W_t = \frac{1.07}{1 + X} \times W_o$$

where:

W_t = desired weight of sample containing 7 per cent moisture at time of test,

W_o = original weight of sample before conditioning, and

X = moisture content of sample.

Note: *Example.*—If $X = 15$ per cent, the sample would be dried to a weight of 0.93 W_0 to contain 7 per cent moisture.

Procedure

6. (*a*) The specimen pieces shall be placed in the wire frame in 12 tiers of two pieces each, 1 in. apart, with the pieces in each tier placed perpendicular to those in the tier below, thus forming a crib (see Fig. 3). The pieces shall be taken from the composite specimen at random and stacked without regard for original position in the sample, unless otherwise specified. The first tier shall be placed on the lower wires of the frame. The first three tiers will then be supported by wires and the remaining nine tiers built up. The spacing of the pieces shall be duplicated by placing each piece in contact with the vertical wires of the frame, permitting approximately equal overhang at the ends as determined by visual inspection. The frame with the stacked crib in place shall be centered on the ring stand. If tests are made in an open room, the flame shield shall be placed around the specimen during the test. If tests are made in a fume hood with draft controlled as specified in Section 2 (*a*), the shield need not be in place around the specimen during the test.

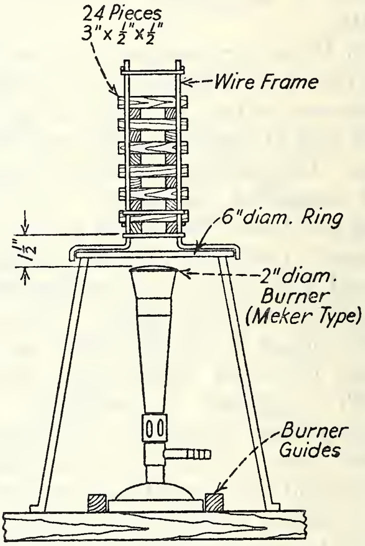

Fig. 3.—Crib Test Assembly.

(*b*) The Meker burner shall be adjusted to produce a blue flame 10 ± ½ in. in height. The air adjustment of the burner shall be set to produce individual blue jets about ¼ in. in height directly over the grid without forming a common inner cone and without causing the grid to glow. With the burner placed under the center of the shield (Fig. 2), the flame shall be regulated to produce a temperature of 600 ± 15 F. (315 ± 8 C.) at the top opening. Calibrations under the shield will afford a convenient check on the flame adjustment between successive tests. Fluctuations in gas pressure shall be determined by the use of a manometer suitably connected to the gas supply, and the pressure regulated to maintain a uniform supply to the burner. A gas-pressure regulator is desirable.

(*c*) The burner, with calibrated flame, shall be placed directly below the center of the crib. To avoid unnecessary centering adjustments, it will be convenient to attach the legs of the ring stand permanently to the work bench and provide a receptacle or guides for the burner to insure quick and accurate placement. The top of the burner grid shall be $1\frac{1}{2}$ in. below the bottom of the lower tier of pieces in the specimen (see Fig. 3). The flame shall be applied for 3 min., after which it shall be removed by withdrawing the burner.

(*d*) The specimen shall not be disturbed until all flaming and glowing has ceased. After glowing has ceased, the specimen, including any pieces that may have fallen, shall be transferred to the scale pan of a balance and weighed.[3] Original and final weights shall be determined to at least the nearest 0.5 g. These weights may be determined with the specimen in the frame, deducting the weight of frame and of nails, if used.

Report

7. The original and final weights, and the moisture content of the specimen shall be recorded. The loss in weight after all flaming and glowing has ceased shall be expressed as a percentage of the original weight of the specimen as tested.[4] Duration of continued flaming and continued glow after removal of the igniting flame shall be recorded.

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[3] Since some glow, not visible, may persist within the charcoal, the operator shall allow a reasonable time before weighing, particularly in the case of poorly treated material. For untreated wood, some charcoal may drop from the crib, and a fine-wire, ½-in. mesh screen placed on top of the ring stand, or a suitable receptacle; may be advisable to avoid loss of material.

[4] Equipment and procedure for measurement of other properties such as rate of weight loss, maximum temperature, and time of flaming and glowing are given in the report on "Comparative Fire Tests of Treated and Untreated Wood," prepared by Subcommittee II on Fire Tests of Lumber, of Committee C-5, see *Proceedings*, Am. Soc. Testing Mats., Vol. 41, p. 238 (1941).

APPROVED AS
AMERICAN STANDARD
BY THE AMERICAN STANDARDS ASSOCIATION
ASA NO.: A2.3-1956
UDC 669.81:691.11:620.1

Standard Method of Test for
COMBUSTIBLE PROPERTIES OF TREATED WOOD BY THE FIRE-TUBE APPARATUS[1]

ASTM Designation: E 69 - 50

Adopted, 1947; Revised, 1950.[2]

Reapproved in 1958 Without Change.

This Standard of the American Society for Testing Materials is issued under the fixed designation E 69; the final number indicates the year of original adoption as standard or, in the case of revision, the year of last revision.

Scope

1. This method covers fire-tube test procedures for fire tests for combustible properties of wood treated to reduce flammability. The test relates to properties of treated wood, as such, rather than to the performance of a fabrication used as an element of construction. Performance under this test shall be as prescribed in requirements applicable to materials intended for specific uses.

Apparatus

2. The apparatus for conducting the fire-tube test shall consist of the fire-tube assembly and accessory equipment as follows:

(*a*) *Fire-Tube Assembly.*—A specially constructed balance designed to indicate directly the percentage loss of weight suffered by the test specimen when exposed to a standardized flame for a given duration. Essential construction details of the apparatus assembly are shown in Figs. 1 and 2.

(*b*) *Igniting Burner.*—An igniting burner of the low-form (curved-stem) bunsen type, having a tube $\frac{3}{8}$ in. in inside diameter, and attached to a ring-stand support. A manometer to indicate the pressure of gas between the regulating cock and the burner shall be used. (A gas-pressure regulator is desirable.)

(*c*) *Temperature-Indicating Apparatus.*—A thermometer or thermocouple equipment that will indicate temperatures up to 392 F. (200 C.).

(*d*) *Timer.*—A timing device capable of being read to minutes and seconds.

(*e*) *Balance.*—A balance capable of being read to 0.1 g. and suitable for weighing test specimens and moisture-content samples.

(*f*) *Oven.*—A suitable thermostatically controlled oven for moisture-content determinations.

Sampling and Test Specimens for Wood Impregnated Throughout Entire Section

3. For interior trim or other lumber

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[1] Under the standardization procedure of the Society, this method is under the jurisdiction of the A.S.T.M. Committee E-5 on Fire Tests of Materials and Construction.

[2] Prior to adoption as standard, this method was published as tentative from 1946 to 1947, being revised in 1947.

requiring penetration of treating solution throughout the section (but not for wood given incomplete penetration), the test specimens shall be prepared as follows:

(*a*) At least one sample shall be taken from the lot for each 5000 bd. ft. or fraction thereof. Different species, and pieces of the same species with widely different thicknesses, shall be considered as separate lots and sampled accordingly. The samples shall be selected so as to include material from different sections of a finished unit or different lengths of finished trim, or to include variations such as heartwood or sapwood, rate of growth, density, and other visible non-uniformities. Samples shall be cut not closer than 2 ft. from the ends of treated boards.

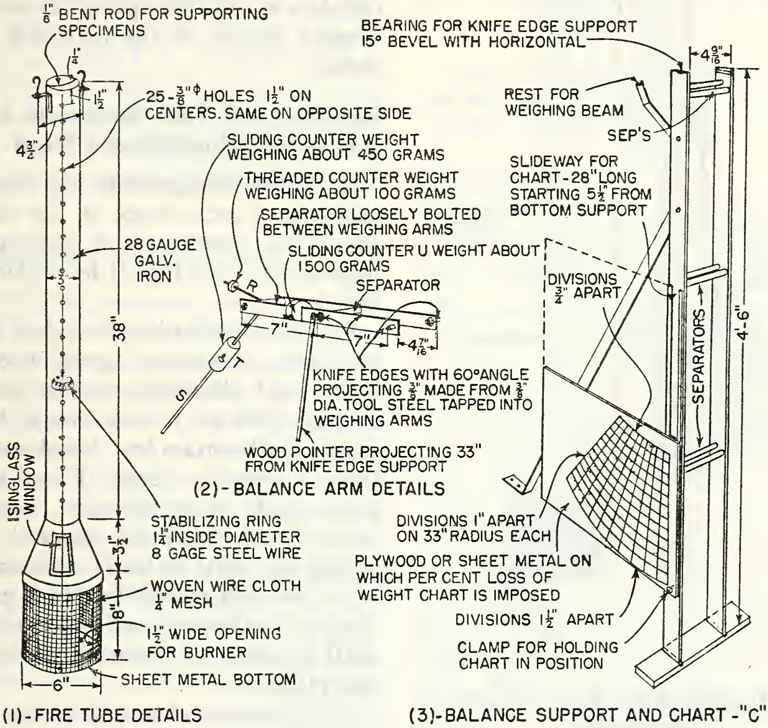
1/8" BENT ROD FOR SUPPORTING SPECIMENS
1/4"
1 1/2"
4 3/4"
25-3/8"ϕ HOLES 1 1/2" ON CENTERS. SAME ON OPPOSITE SIDE
28 GAUGE GALV. IRON
3"
38"
ISINGLASS WINDOW
STABILIZING RING 1 1/4" INSIDE DIAMETER 8 GAGE STEEL WIRE
3 1/2"
8"
WOVEN WIRE CLOTH 1/4" MESH
1 1/2" WIDE OPENING FOR BURNER
SHEET METAL BOTTOM
6"
(1)-FIRE TUBE DETAILS
SLIDING COUNTER WEIGHT WEIGHING ABOUT 450 GRAMS
THREADED COUNTER WEIGHT WEIGHING ABOUT 100 GRAMS
SEPARATOR LOOSELY BOLTED BETWEEN WEIGHING ARMS
SLIDING COUNTER U WEIGHT ABOUT 1500 GRAMS
SEPARATOR
R
T
S
7"
7"
4 7/16"
KNIFE EDGES WITH 60° ANGLE PROJECTING 3/8" MADE FROM 3/8" DIA. TOOL STEEL TAPPED INTO WEIGHING ARMS
WOOD POINTER PROJECTING 33" FROM KNIFE EDGE SUPPORT
(2)-BALANCE ARM DETAILS
BEARING FOR KNIFE EDGE SUPPORT 15° BEVEL WITH HORIZONTAL
4 9/16"
REST FOR WEIGHING BEAM
SEP'S
SLIDEWAY FOR CHART-28" LONG STARTING 5 1/2" FROM BOTTOM SUPPORT
DIVISIONS 3/4" APART
SEPARATORS
4'-6"
DIVISIONS 1" APART ON 33" RADIUS EACH
PLYWOOD OR SHEET METAL ON WHICH PER CENT LOSS OF WEIGHT CHART IS IMPOSED
DIVISIONS 1 1/2" APART
CLAMP FOR HOLDING CHART IN POSITION
(3)-BALANCE SUPPORT AND CHART -"C"

Fig. 1.—Construction Details of Fire-Tube Apparatus.

(*b*) Not less than 5 tests shall be made from each sample, except that where the quantity is less than 2000 bd. ft. the number of tests shall be left to the discretion of the testing authority but shall be not less than two.

(*c*) The standard specimens cut from the selected samples shall be $\frac{3}{8}$ by $\frac{3}{4}$ in. in cross-section by 40 in. in length, with surfaces smooth-sawed to dimensions within plus or minus $\frac{1}{32}$ in. Each test specimen may consist of one piece sawed the full 40-in. length or may be made up of several shorter pieces joined at squared ends with six small wire staples at each joint to give a combined length of 40 in.

(*d*) From samples taken from boards having thicknesses of $\frac{3}{4}$ in. or more, the specimen shall be prepared by cutting $\frac{3}{8}$ by $\frac{3}{4}$-in. pieces longitudinally, not nearer than $\frac{3}{8}$ in. from the edge of the sample, and so that the face of the sample appears as one, or both, of the $\frac{3}{8}$-in. edges of the specimen; provided, however, that if the thickness of the sample exceeds $1\frac{1}{2}$ in. an additional test specimen shall be cut from the center of the piece with the $\frac{3}{8}$-in. edge parallel to the edge of the sample.

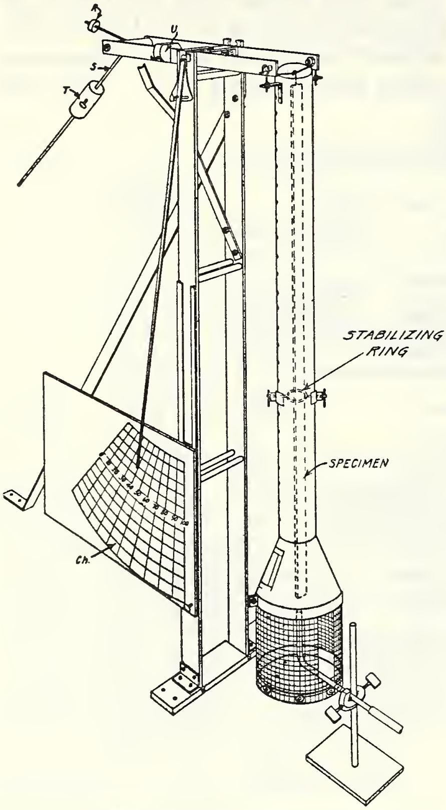

Fig. 2.—Assembly of Fire-Tube Apparatus for Procedure A.

(*e*) From samples taken from boards having thicknesses of $\frac{3}{8}$ in. or more but less than $\frac{3}{4}$ in., the specimen shall be prepared by cutting $\frac{3}{8}$ by $\frac{3}{4}$-in. pieces longitudinally not nearer than $\frac{3}{8}$ in. from the edge of the same and so that the face of the sample appears as one, or both, of the $\frac{3}{4}$-in. faces of the specimen.

(*f*) When the material to be tested is less than $\frac{3}{8}$ in. in thickness, the specimen may be built up in laminated form with plies of approximately equal thickness. The plies shall be dressed smooth and assembled by nailing with $\frac{3}{8}$-in. steel-wire brads (No. 20 B.w.g., 0.035-in. nominal thickness). The weight of nails used shall be recorded for correction of the weight of the specimen.

(*g*) A composite specimen prepared from more than one sample piece shall be taken so as to be representative of the average quality of the materials to be tested.

Sampling and Test Specimens for Incompletely Impregnated Wood

4. Where arrangements are made for sampling of each charge at the treating plant, the specimens of incompletely impregnated wood shall be obtained as follows:

(*a*) One sample piece furnished by the purchaser, previously agreed upon, selected, and identified, shall be included for each 5000 bd. ft. in a charge, but no charge shall contain less than 4 nor more than 8 sample pieces. These sample pieces shall be of the same species of wood as the rest of the material in the charge and shall be fairly representative of the lot with respect to rate of growth, density, heartwood, and sapwood. They shall be identified by metal tags or the equivalent.

(*b*) Placement of sample pieces in the material to be treated on a tram shall be representative of the average exposure to the treating solution and yet be accessible for ready removal without seriously disturbing the loading.

(*c*) Sample pieces shall be at least 8 ft. in length and may be either full-size rough or dressed standard. They shall be of the same cross-sectional dimensions as the material in the lot for thicknesses up to and including 3 in. in nominal thickness. Where material in the charge is over 3 in. in thickness, irrespective of width, sample pieces shall be 4 by 4 in. in nominal size.

(*d*) Two fire-tube test specimens shall be cut from each selected sample and shall be $\frac{3}{8}$ by $\frac{3}{4}$ in. in cross-section and 42 in. in length, smooth-sawed to dimensions within plus or minus $\frac{1}{32}$ in. A 2-in. length thereof shall be cut off for moisture test specimens. The specimens shall not be cut closer than 2 ft. from ends of sample pieces nor closer than $\frac{1}{2}$ in. from their edges. The specimens shall be cut so that one side $\frac{3}{4}$ in. in width will be from a treated face of the sample piece and shall be cut or chosen from locations fairly representative of density, heartwood, and sapwood for the piece as a whole.

Conditioning of Test Specimens

5. (*a*) The moisture content of the specimen when tested shall be 7 ± 3 per cent by weight of the dry material. The moisture determination for each specimen shall be made on a piece $\frac{3}{8}$ by $\frac{3}{4}$ in. in cross-section and not less than 2 in. in length, cut adjacent to one end of the specimens. The moisture test specimen shall be weighed to the nearest 0.1 g. or less and dried for 24 hr. at 212 ± 3 F. (100 ± 1.7 C.) The weight of the test specimen shall be recorded at the time of weighing the moisture test specimen. If the moisture content exceeds 10 per cent, the sample or prepared specimen shall be conditioned by drying at temperatures not exceeding 150 F. (65 C.) until the moisture content is within the prescribed limits. Low moisture content can be increased by storage in air on a screen over a pan of water. If not tested immediately, the specimen shall be stored, after conditioning, in such a manner as to prevent absorption or loss of water.

(*b*) The weight to which the specimen must be conditioned to contain 7 per cent moisture shall be calculated as follows:

$$W_t = \frac{1.07}{1 + X} \times W_o$$

where:

W_t = desired weight of the specimen containing 7 per cent moisture at time of test,

W_o = original weight of the specimen before conditioning, and

X = moisture content of the specimen, per cent.

Note.—If, for example, $X = 15$ per cent, the specimen would be dried to a weight of 0.93 W_o to contain 7 per cent moisture.

Procedure A

6. (*a*) Procedure A shall be used where a continuous check on the percentage loss of weight of specimens during exposure to the flame is to be made.

(*b*) The test shall be conducted either in a room free of violent drafts or in a laboratory hood.

(*c*) *Adjustment of Burner.*—The burner shall be adjusted to give a blue flame approximately 11 in. in height, with a tall indistinct inner cone. Placed within the empty fire tube, so that the top of the burner is even with the top of the opening in the screen section, the flame shall be further regulated to produce a temperature of 356 ± 9 F. (180 ± 5 C.) at the top of the fire tube. A manometer shall be used in regulating the gas pressure and in maintaining a constant gas supply to the burner after the flame has been adjusted, unless a suitable gas-pressure regulator is employed. When the adjustment is satisfactory the lighted burner shall be withdrawn from the fire tube.

(*d*) *Adjustment of Fire-Tube Weighing Apparatus.*—After assurance that the beam and fire tube swing freely on their respective knife edges, the apparatus shall be adjusted (Note) as follows so that the end of the pointer comes to rest:

(*1*) At the 100 per cent mark on the loss-of-weight chart when the previously warmed fire tube is empty except for a screw hook used for suspending the specimen, and

(*2*) At the 0 per cent mark when the fire tube contains the suspended specimen.

Note.—Adjustment (*1*) is made by suitable manipulation of the counter-weights *R* and *T* (Fig. 1), with rod *S* forming an angle of approximately 45 deg. with the vertical. Adjustment (*2*) is made by appropriately raising or lowering chart *C*. To obtain both adjustments with abnormally heavy or light specimens it may be necessary to rotate the rod *S* more toward the horizontal or vertical position or to change the position of weight *U*. The knife edges of the beam will operate most satisfactorily when the pointer indicates 50 on the chart with the beam in an approximately horizontal position.

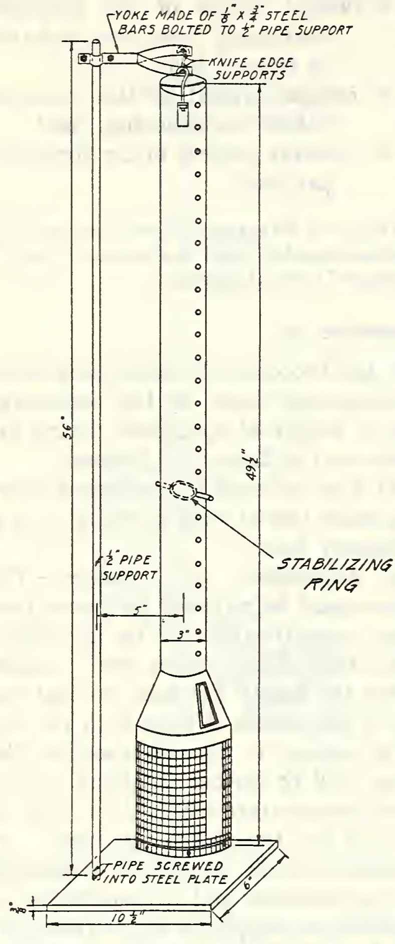
YOKE MADE OF $\frac{1}{8}$" X $\frac{3}{4}$" STEEL BARS BOLTED TO $\frac{1}{2}$" PIPE SUPPORT
KNIFE EDGE SUPPORTS
56"
49$\frac{1}{2}$"
STABILIZING RING
$\frac{1}{2}$" PIPE SUPPORT
5"
3"
PIPE SCREWED INTO STEEL PLATE
6"
10$\frac{1}{2}$"
$\frac{3}{8}$"

Fig. 3.—Assembly of Fire-Tube Apparatus for Procedure B.

(*e*) *Exposure of Test Specimen.*—The lighted burner shall be inserted within the fire tube so that the top of the burner is 1 in. below the lower extremity of the specimen with the standardized flame centered on the specimen. The flame shall be applied to the test specimen for 4 min. after which it shall be withdrawn from the fire tube.

(*f*) *Observations.*—Record shall be made, at $\frac{1}{2}$-min. intervals, of the percentage loss of weight suffered by the test specimen as indicated by the end of the pointer on the percentage-loss-of-weight chart, until the loss of weight for a 1-min. period does not exceed 1 per cent. The percentage loss of weight shall be considered a measure of the combustibility of the specimen.

Procedure B

7. (*a*) Procedure B may be used where only the final percentage loss of weight of specimens exposed to the flame is to be reported. It is an abridged form of procedure A.

(*b*) The specially constructed balancing parts of the fire-tube apparatus, as described in Section 2(*a*), may be eliminated. Under such conditions the fire-tube elements of the apparatus (shown in Fig. 1) shall be supported in a vertical position by suspending the tube from the top as shown in Fig. 3 or by means of a clamp or other suitable supports for holding the tube vertical.

(*c*) The final percentage loss of weight shall be calculated from the initial and final weights of the test specimen as obtained by means of the balance described in Section 2(*e*).

Report

8. The report shall include the following:

(*1*) The percentage moisture content of the test specimens,

(*2*) The final percentage loss of weight of each specimen after all flaming and glowing has ceased, and

(*3*) The percentage loss of weight at an intermediate exposure period for each specimen, if so specified in the acceptance requirements for the material tested.

Standard Methods of

FIRE TESTS OF BUILDING CONSTRUCTION AND MATERIALS[1]

ASTM Designation: E 119 – 58

(*Formerly Designated C 19*)

Adopted, 1933; Revised, 1941, 1947, 1950, 1953, 1954, 1955, 1958.[2]

This Standard of the American Society for Testing Materials is issued under the fixed designation E 119; the final number indicates the year of original adoption as standard or, in the case of revision, the year of last revision.

The performance of walls, columns, floors, and other building members under fire exposure conditions is an item of major importance in securing constructions that are safe, and that are not a menace to neighboring structures nor to the public. Recognition of this is registered in the codes of many authorities, municipal and other. It is important to secure balance of the many units in a single building, and of buildings of like character and use in a community; and also to promote uniformity in requirements of various authorities throughout the country. To do this it is necessary that the fire-resistive properties of materials and assemblies be measured and specified according to a common standard expressed in terms that are applicable alike to a wide variety of materials, situations, and conditions of exposure.

Such a standard is found in the methods that follow. They prescribe a standard exposing fire of controlled extent and severity. Performance is defined as the period of resistance to standard exposure elapsing before the first critical point in behavior is observed. Results are reported in units in which field exposures can be judged and expressed.

The methods may be cited as the "Standard Fire Tests," and the performance or exposure shall be expressed as "2-hr," "6-hr," "½-hr," etc.

When a factor of safety exceeding that inherent in the test conditions is desired, a proportional increase should be made in the specified time-classification period.

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[1] Under the standardization procedure of the Society, these methods are under the jurisdiction of the ASTM Committee E-5 on Fire Tests of Materials and Construction.

These methods, of which the present standard represents a revision, were prepared by Sectional Committee A2 on Fire Tests of Materials and Construction, under the joint sponsorship of the National Bureau of Standards, the ASA Fire Protection Group, and the American Society for Testing Materials, functioning under the procedure of the American Standards Association.

[2] Prior to their present adoption as standard, these methods were published as tentative from 1917 to 1918, being revised in 1918. They were adopted in 1918, but withdrawn and republished as tentative from 1926 to 1933, being revised in 1933.

Scope

1. (*a*) These methods of fire tests are applicable to assemblies of masonry units and to composite assemblies of structural materials for buildings, including bearing and other walls and partitions, columns, girders, beams, slabs, and composite slab and beam assemblies for floors and roofs. They are also applicable to other assemblies and structural units that constitute permanent integral parts of a finished building.

(*b*) It is the intent that classifications shall register performance during the period of exposure and shall not be construed as having determined suitability for use after fire exposure.

Note.—A method of fire hazard classification based on rate of flame spread is covered in the Method of Fire Hazard Classification of Building Materials (ASTM Designation: E 84).[3]

Control of Fire Tests

Time-Temperature Curve

2. The conduct of fire tests of materials and construction shall be controlled by the standard time-temperature curve shown in Fig. 1. The points on the curve that determine its character are:

1000 F (538 C)	at 5 min
1300 F (704 C)	at 10 min
1550 F (843 C)	at 30 min
1700 F (927 C)	at 1 hr
1850 F (1010 C)	at 2 hr
2000 F (1093 C)	at 4 hr
2300 F (1260 C)	at 8 hr or over

For a closer definition of the time-temperature curve, see the Appendix.

Furnace Temperatures

3. (*a*) The temperature fixed by the curve shall be deemed to be the average temperature obtained from the readings of not less than nine thermocouples for a floor, roof, wall, or partition and not less than eight thermocouples for a structural column symmetrically disposed and distributed to show the temperature near all parts of the sample, the thermocouples being enclosed in sealed porcelain tubes $\frac{3}{4}$ in. in outside diameter and $\frac{1}{8}$ in. in wall thickness, or, as an alternative in the case of base metal thermocouples, enclosed in sealed, standard-weight, $\frac{1}{2}$-in., black wrought steel or black wrought iron pipe. The exposed length of the pyrometer tube and thermocouple in the furnace chamber shall be not less than 12 in. Other types of protecting tubes or pyrometers may be used that, under test conditions, give the same indications as the above standard within the limit of accuracy that applies for furnace-temperature measurements. For floors and columns, the junction of the thermocouples shall be placed 12 in. away from the exposed face of the sample at the beginning of the test and, during the test, shall not touch the sample as a result of its deflection. In the case of walls and partitions, the thermocouples shall be placed 6 in. away from the exposed face of the sample at the beginning of the test,

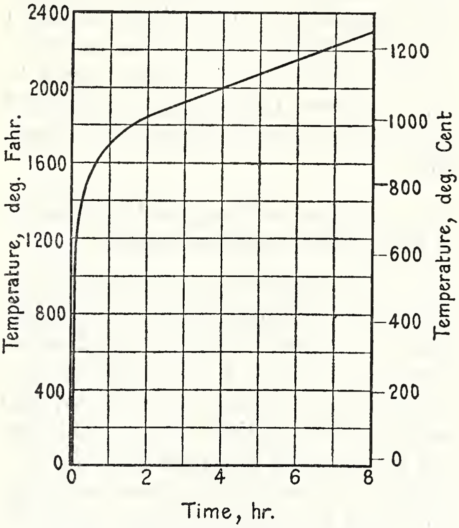

Fig. 1.—Time-Temperature Curve.

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[3] See p. 390.

and shall not touch the sample during the test, in the event of deflection.

(*b*) The temperatures shall be read at intervals not exceeding 5 min during the first 2 hr, and thereafter the intervals may be increased to not more than 10 min.

(*c*) The accuracy of the furnace control shall be such that the area under the time-temperature curve, obtained by averaging the results from the pyrometer readings, is within 10 per cent of the corresponding area under the standard time-temperature curve shown in Fig. 1 for fire tests of 1 hr or less duration, within 7.5 per cent for those over 1 hr and not more than 2 hr, and within 5 per cent for tests exceeding 2 hr in duration.

Temperatures of Unexposed Surfaces of Floors, Walls, and Partitions

4. (*a*) Temperatures at unexposed surfaces shall be measured with thermocouples or thermometers[4] placed under flexible, oven-dry, felted asbestos pads 6 in. square, 0.4 in. in thickness, and weighing not less than 1.0 nor more than 1.4 lb per sq ft. The pads shall be sufficiently soft so that, without breaking, they may be shaped to contact over the whole surface against which they are placed. The wire leads of the thermocouple or the stem of the thermometer shall have an immersion under the pad and be in contact with the unexposed surface for not less than 3½ in. The hot junction of the thermocouple or the bulb of the thermometer shall be placed approximately under the center of the pad. The outside diameter of protecting or insulating tubes, and of thermometer stems, shall be not more than $\frac{5}{16}$ in. The pad shall be held firmly against the surface, and shall fit closely about the thermocouples or thermometer stems. Thermometers shall be of the partial-immersion type, with a length of stem, between the end of the bulb and the immersion mark, of 3 in. The wires for the thermocouple in the length covered by the pad shall be not heavier than No. 18 B & S gage (0.04 in.) and shall be electrically insulated with heat-resistant and moisture-resistant coatings.

(*b*) Temperature readings shall be taken at not less than nine points on the surface. Five of these shall be symmetrically disposed, one to be approximately at the center of the specimen, and four at approximately the center of its quarter sections. The other four shall be located at the discretion of the testing authority to obtain representative information on the performance of the construction under test. None of the thermocouples shall be nearer than one and one-half times the thickness of the construction, or nearer than 12 in. to the edges, and none of them shall be located opposite or on top of beams, girders, pilasters, or other structural members if temperatures at such points will obviously be lower than at more representative locations.

(*c*) Temperature readings shall be taken at intervals not exceeding 15 min. until a reading exceeding 212 F (100 C) has been obtained at any one point. Thereafter the readings may be taken more frequently at the discretion of the testing body, but the intervals need not be less than 5 min.

(*d*) Where the conditions of acceptance place a limitation on the rise of temperature of the unexposed surface, the temperature end point of the fire endurance period shall be determined by the average of the measurements taken at individual points; except that if a temperature rise 30 per cent in excess of the specified limit occurs at any one of these points, the remainder shall be ignored and the fire endurance period judged as ended.

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[4] Under certain conditions it may be unsafe or impracticable to use thermometers.

Classification as Determined by Test

Report of Results

5. (*a*) Results shall be reported in accordance with the performance in the tetts prescribed in these methods. They shall be expressed in time periods of resistance, to the nearest integral minute. Reports shall include observations of significant details of the behavior of the material or construction during the test and after the furnace fire is cut off, including information on deformation, spalling, cracking, burning of the specimen or its component parts, continuance of flaming, and production of smoke.

(*b*) Reports of tests involving wall, floor, beam, or ceiling constructions in which restraint is provided against expansion, contraction, or rotation of the construction shall describe the method used to provide this restraint.

(*c*) When the indicated resistance period is ½ hr or over, determined by the average or maximum temperature rise on the unexposed surface or within the test sample, or by failure under load, a correction shall be applied for variation of the furnace exposure from that prescribed, where it will affect the classification, by multiplying the indicated period by two thirds of the difference in area between the curve of average furnace temperature and the standard curve for the first three fourths of the period and dividing the product by the area between the standard curve and a base line of 68 F (20 C) for the same part of the indicated period, the latter area increased by 54 Fahr-hr or 30 Cent-hr (3240 Fahr-min or 1800 Cent-min), to compensate for the thermal lag of the furnace thermocouples during the first part of the test. For fire exposure in the test higher than standard, the indicated resistance period shall be increased by the amount of the correction and be similarly decreased for fire exposure below standard (Note).

Note.—The correction can be expressed by the following formula:

$$C = \frac{2I(A - A_s)}{3(A_s + L)}$$

where:

C = correction in the same units as I,

I = indicated fire-resistance period,

A = area under the curve of indicated average furnace temperature for the first three fourths of the indicated period,

A_s = area under the standard furnace curve for the same part of the indicated period, and

L = lag correction in the same units as A and A_s (54 Fahr-hr or 30 Cent-hr (3240 Fahr-min or 1800 Cent-min)).

Test Sample

Test Sample

6. (*a*) The test sample shall be truly representative of the construction for which classification is desired, as to materials, workmanship, and details such as dimensions of parts, and shall be built under conditions representative of those obtaining as practically applied in building construction and operation. The physical properties of the materials and ingredients used in the test sample shall be determined and recorded.

(*b*) The size and dimensions of the test sample specified herein are intended to apply for rating constructions of dimensions within the usual general range employed in buildings. If the conditions of use limit the construction to smaller dimensions, a proportionate reduction may be made in the dimensions of the samples for a test qualifying them for such restricted use.

Conduct of Fire Tests

Fire Endurance Test

7. The fire endurance test on the sample with its applied load, if any, shall be continued until failure occurs, or until the sample has withstood the test conditions for a period equal to that herein specified in the conditions of

acceptance for the given type of construction.

Hose Stream Test

8. (*a*) Where required by the conditions of acceptance, a duplicate sample shall be subjected to a fire exposure test for a period equal to one half of that indicated as the resistance period in the fire endurance test, but not for more than 1 hr, immediately after which the sample shall be subjected to the impact, erosion, and cooling effects of a hose stream directed first at the middle and then at all parts of the exposed face, changes in direction being made slowly.

TABLE I.—CONDITIONS FOR HOSE STREAM TEST.

Resistance Period	Water Pressure at Base of Nozzle, psi	Duration of Application, min per 100 sq ft exposed area
8 hr and over	45	6
4 hr and over if less than 8 hr	45	5
2 hr and over if less than 4 hr	30	2½
1½ hr and over if less than 2 hr	30	1½
1 hr and over if less than 1½ hr	30	1
Less than 1 hr, if desired	30	1

(*b*) *Exemption.*—The hose stream test shall not be required in the case of constructions having a resistance period, indicated in the fire endurance test, of less than 1 hr.

(*c*) *Optional Program.*—The submitter may elect, with the advice and consent of the testing body, to have the hose stream test made on the sample subjected to the fire endurance test and immediately following the expiration of the fire endurance test.

(*d*) *Stream Equipment and Details.*—The stream shall be delivered through 2½-in. hose discharging through a National Standard Playpipe of corresponding size equipped with a 1⅛-in. discharge tip of the standard-taper smooth-bore pattern without shoulder at the orifice. The water pressure and duration of application shall be as prescribed in Table I.

(*e*) *Nozzle Distance.*—The nozzle orifice shall be 20 ft from the center of the exposed surface of the test sample if the nozzle is so located that when directed at the center its axis is normal to the surface of the test sample. If otherwise located, its distance from the center shall be less than 20 ft by an amount equal to 1 ft for each 10 deg of deviation from the normal.

Time of Testing

9. The material or construction shall not be tested until a large proportion of its final strength has been attained, and, if it contains free water, until the excess has been given off. Whenever practicable, the material or construction shall be weighed at intervals during the period of drying and the weights on successive days recorded. Weighing shall be continued until the weight shall have remained fundamentally constant for not less than 5 successive days under favorable drying conditions of the open room of the laboratories. If weighing of the total material or construction of the test specimen is not practicable, a suitable sample designed to give an accurate estimate of the condition of dryness of the complete sample shall be selected or fabricated and subjected to weighing as specified above for the complete test specimen. Artificial drying at temperatures not injurious to the material or construction to be tested may be used.

TESTS OF BEARING WALLS AND PARTITIONS

Size of Sample

10. The area exposed to fire shall be not less than 100 sq ft, with neither

dimension less than 9 ft. The test specimen shall not be restrained on its vertical edges.

Loading

11. During the fire endurance and fire and hose stream tests a superimposed load shall be applied to the construction in a manner calculated to develop theoretically, as nearly as practicable, the working stresses contemplated by the design.

Conditions of Acceptance

12. The test shall be regarded as successful if the following conditions are met:

(*a*) The wall or partition shall have sustained the applied load during the fire endurance test without passage of flame or gases hot enough to ignite cotton waste, for a period equal to that for which classification is desired.

(*b*) The wall or partition shall have sustained the applied load during the fire and hose stream test as specified in Section 8, without passage of flame, of gases hot enough to ignite cotton waste, or of the hose stream, and after cooling but within 72 hr after its completion shall sustain the dead load of the test construction plus twice the superimposed load specified above.

(*c*) Transmission of heat through the wall or partition during the fire endurance test shall not have been such as to raise the temperature on its unexposed surface more than 250 F (139 C) above its initial temperature.

TESTS OF NONBEARING WALLS AND PARTITIONS

Size of Sample

13. The area exposed to fire shall be not less than 100 sq ft, with neither dimension less than 9 ft. The test specimen shall be restrained on all four edges.

Conditions of Acceptance

14. The test shall be regarded as successful if the following conditions are met:

(*a*) The wall or partition shall have withstood the fire endurance test without passage of flame or gases hot enough to ignite cotton waste, for a period equal to that for which classification is desired.

(*b*) The wall or partition shall have withstood the fire and hose stream test as specified in Section 8, without passage of flame, of gases hot enough to ignite cotton waste, or of the hose stream.

(*c*) Transmission of heat through the wall or partition during the fire endurance test shall not have been such as to raise the temperature on its unexposed surface more than 250 F (139 C) above its initial temperature.

TESTS OF COLUMNS

Size of Sample

15. The length of the column exposed to fire shall, when practicable, approximate the maximum clear length contemplated by the design, and for building columns shall be not less than 9 ft. The contemplated details of connections, and their protection if any, shall be applied according to the methods of acceptable field practice.

Loading

16. (*a*) During the fire endurance test the column shall be exposed to fire on all sides and shall be loaded in a manner calculated to develop theoretically, as nearly as practicable, the working stresses contemplated by the design. Provision shall be made for transmitting the load to the exposed portion of the column without unduly increasing the effective column length.

(*b*) If the submitter and the testing body jointly so decide, the column may be subjected to $1\frac{3}{4}$ times its designed working load before the fire endurance test is undertaken. The fact that such a test has been made shall not be construed as having had a deleterious effect on the fire endurance test performance.

Condition of Acceptance

17. The test shall be regarded as successful if the column sustains the applied load during the fire endurance test for a period equal to that for which classification is desired.

ALTERNATE TEST OF PROTECTION FOR STRUCTURAL STEEL COLUMNS

Application

18. This test procedure does not require column loading at any time and may be used at the discretion of the testing laboratory to evaluate steel column protections that are not required by design to carry any of the column load.

Size and Character of Sample

19. (*a*) The size of the steel column used shall be such as to provide a test specimen that is truly representative of the design, materials, and workmanship for which classification is desired. The protection shall be applied according to the methods of acceptable field practice. The length of the protected column shall be at least 8 ft. The column shall be vertical during application of the protection and during the fire exposure.

(*b*) The applied protection shall be restrained against longitudinal temperature expansion greater than that of the steel column by rigid steel plates or reinforced concrete attached to the ends of the steel column before the protection is applied. The size of the plates or amount of concrete shall be adequate to provide direct bearing for the entire transverse area of the protection.

(*c*) The ends of the specimen, including the means for restraint shall be given sufficient thermal insulation to prevent appreciable direct heat transfer from the furnace.

Temperature Measurement

20. The temperature of the steel in the column shall be measured by at least three thermocouples located at each of four levels. The upper and lower levels shall be 2 ft from the ends of the steel column, and the two intermediate levels shall be equally spaced. The thermocouples at each level shall be so placed as to measure significant temperatures of the component elements of the steel section.

Exposure to Fire

21. During the fire endurance test the specimen shall be exposed to fire on all sides for its full length.

Conditions of Acceptance

22. The test shall be regarded as successful if the transmission of heat through the protection during the period of fire exposure for which classification is desired does not raise the average (arithmetical) temperature of the steel at any one of the four levels above 1000 F, or does not raise the temperature above 1200 F at any one of the measured points.

TESTS OF FLOORS AND ROOFS

(The following contemplates application of fire exposure to the under side of constructions.)

Size and Construction of Sample

23. (*a*) The area exposed to fire shall be not less than 180 sq ft, with neither dimension less than 12 ft. Beams or girders, if a part of the construction under test, shall lie within the combustion chamber and have a clearance of not less than 8 in. from its walls.

(*b*) Beams or joists forming part of the assembly shall be supported in accordance with the recommended fabrication procedures for the type of construction. Assemblies representing forms of construction that restrain structural elements and top deck shall be supported by a restraining frame incorporated in the furnace structure stimulating such restraint.

Loading

24. During the fire endurance test a superimposed load shall be applied to the construction in a manner calculated to develop theoretically, as nearly as practicable, the working stresses in each member contemplated by the design.

Conditions of Acceptance

25. The test shall be regarded as successful if the following conditions are met:

(*a*) The construction shall have sustained the applied load during the fire endurance test without passage of flame or gases hot enough to ignite cotton waste, for a period equal to that for which classification is desired.

(*b*) Transmission of heat through the construction during the fire endurance test shall not have been such as to raise the temperature on its unexposed surface more than 250 F (139 C) above its initial temperature.

ALTERNATE TEST OF PROTECTION FOR SOLID STRUCTURAL STEEL BEAMS AND GIRDERS

Application

26. Where the loading required in Section 24 is not feasible, this alternate test procedure may be used to evaluate the protection of steel beams and girders without application of design load, provided that the protection is not required by design to function structurally in resisting applied loads. The conditions of acceptance of this alternate test are not applicable to tests made under design load as provided under tests for floors and roofs in Sections 23 and 25.

Size and Character of Sample

27. (*a*) The size of the steel beam or girder shall be such as to provide a test specimen that is truly representative of the design, materials, and workmanship for which classification is desired. The protection shall be applied according to the methods of acceptable field practice and the projection below the ceiling, if any, shall be representative of the conditions of intended use. The length of beam or girder exposed to the fire shall be not less than 12 ft and the member shall be tested in a horizontal position. A section of a representative floor construction not less than 5 ft wide, symmetrically located with reference to the beam or girder and extending its full length, shall be included in the test assembly and exposed to fire from below. The rating of performance shall not be applicable to sizes smaller than those tested.

(*b*) The applied protection shall be restrained against longitudinal expansion greater than that of the steel beam or girder by rigid steel plates or reinforced concrete attached to the ends of the member before the protection is applied. The ends of the member, including the means for restraint, shall be given sufficient thermal insulation to prevent appreciable direct heat transfer from the furnace to the unexposed ends of the member or from the ends of the member to the outside of the furnace.

Temperature Measurement

28. The temperature of the steel in the beam or girder shall be measured with not less than four thermocouples at each of four sections equally spaced along the length of the beam and symmetrically disposed and not nearer than 2 ft from the inside face of the furnace. The thermocouples at each section shall be sym-

metrically placed so as to measure significant temperatures of the component elements of the steel section.

Conditions of Acceptance

29. The test shall be regarded as successful if the transmission of heat through the protection during the period of fire exposure for which classification is desired does not raise the average (arithmetical) temperature of the steel at any one of the four sections above 1000 F, or does not raise the temperature above 1200 F at any one of the measured points.

TESTS OF CEILING CONSTRUCTIONS

Size of Sample

30. The area exposed to fire shall be not less than 180 sq ft, with neither dimension less than 12 ft, and the ceiling surface at its edges shall be in contact with the test furnace structure.

Test Construction and Enclosure

31. The test ceiling construction shall include all structural members and details including hangers, if any, but not walkways. Above the ceiling during the test, there shall be provided a tight flat-topped enclosure, the underside of the covering material of which shall be 36 in. above the top of the joists or beams supporting and protected by the ceiling. The top of the enclosure shall be made of cement-asbestos board $\frac{1}{4}$ in. in thickness under asbestos millboard $\frac{1}{2}$ in. in thickness, and the side walls of 8-in. common brick, or it shall be of a construction having equivalent heat conductivity and heat capacity. Where use of the ceiling under a combustible construction is contemplated, at least five 15-in. square panels of 1-in. pine boards shall be attached to the underside of the top of the enclosure. The temperatures on the bottom surface of these panels shall be measured.

Conditions of Acceptance

32. The test shall be regarded as successful if the following conditions are met:

(*a*) The ceiling shall have withstood the fire endurance test without the passage of flame or ignition of combustible members or materials forming part of the construction above the ceiling as evidenced by glow or flame.

(*b*) Transmission of heat through the ceiling during the fire endurance test shall not have been such as to raise the average temperature above the test ceiling more than indicated in the following Items (*1*), (*2*), and (*3*). The limiting temperatures shall be the average of those taken at not less than five points, one of which shall be approximately at the center, and four at approximately the centers of the quarter sections.

(*1*) With combustible supports or other combustible material in contact with the ceiling, the temperature increase at the points of contact shall not exceed 250 F.

(*2*) With combustible supports or other combustible material not in contact with the ceiling, the temperature increase on the surface of any combustible members, pine panels, or combustible material adjacent to the ceiling shall not exceed 250 F. The temperature on the exposed surface of combustible members not in contact with the ceiling shall be measured under a sheet of mica approximately 0.002 in. in thickness.

(*3*) With no combustible material above the ceiling construction, the average temperature measured on the lower surface of the main structural supporting members (beams or slabs) shall not exceed 1200 F and the average temperature of the top and bottom of the beams, when used, shall not exceed 1000 F.

Tests of Protection for Combustible Framing, or for Combustible Facings on the Unexposed Sides of Walls, Partitions, and Floors

Character of Sample

33. Test panels carrying wall, partition, or floor protection shall be finished with the protections which are the subject of the test, except that where the finish on the unexposed side is not the subject of the test and is not specifically indicated, the testing authority shall apply a finish judged suitable for the purpose. In case a floor construction, as installed for actual use, is to have no finish on the unexposed side, it shall be so tested.

Size of Sample

34. The area exposed to fire shall be, for tests of wall and partition protection, not less than 100 sq ft with neither dimension less than 9 ft; for tests of floor protection, not less than 180 sq ft with neither dimension less than 12 ft.

Conditions of Acceptance

35. The test shall be regarded as successful if the following conditions are met:

(*a*) The protection shall have withstood the fire endurance test, without ignition of the materials protected, for a period equal to that for which classification is desired.

(*b*) Transmission of heat through the protection during the fire endurance test shall not have been such as to raise the temperatures at its contact with the protected structural members or facings of the test panel more than 250 F (139 C) above the initial temperatures at these points, except that for members closely embedded on three sides in masonry, concrete, or other incombustible materials the permissible temperature rise may be 325 F (181 C).

(See Appendix, p. 384.)

APPENDIX

TABLE II.—STANDARD TIME-TEMPERATURE CURVE FOR CONTROL OF FIRE TESTS.

Time	Temperature, deg Fahr	Area Above 68 F Base		Temperature, deg Cent	Area Above 20 C Base	
hr:min		deg Fahr-min	deg Fahr-hr		deg Cent-min	deg Cent-hr
0:00	68	00	0	20	00	0
0:05	1 000	2 330	39	538	1 290	22
0:10	1 300	7 740	129	704	4 300	72
0:15	1 399	14 150	236	760	7 860	131
0:20	1 462	20 970	350	795	11 650	194
0:25	1 510	28 050	468	821	15 590	260
0:30	1 550	35 360	589	843	19 650	328
0:35	1 584	42 860	714	862	23 810	397
0:40	1 613	50 510	842	878	28 060	468
0:45	1 638	58 300	971	892	32 390	540
0:50	1 661	66 200	1 103	905	36 780	613
0:55	1 681	74 220	1 237	916	41 230	687
1:00	1 700	82 330	1 372	927	45 740	762
1:05	1 718	90 540	1 509	937	50 300	838
1:10	1 735	98 830	1 647	946	54 910	915
1:15	1 750	107 200	1 787	955	59 560	993
1:20	1 765	115 650	1 928	963	64 250	1 071
1:25	1 779	124 180	2 070	971	68 990	1 150
1:30	1 792	132 760	2 213	978	73 760	1 229
1:35	1 804	141 420	2 357	985	78 560	1 309
1:40	1 815	150 120	2 502	991	83 400	1 390
1:45	1 826	158 890	2 648	996	88 280	1 471
1:50	1 835	167 700	2 795	1 001	93 170	1 553
1:55	1 843	176 550	2 942	1 006	98 080	1 635
2:00	1 850	185 440	3 091	1 010	103 020	1 717
2:10	1 862	203 330	3 389	1 017	112 960	1 882
2:20	1 875	221 330	3 689	1 024	122 960	2 049
2:30	1 888	239 470	3 991	1 031	133 040	2 217
2:40	1 900	257 720	4 295	1 038	143 180	2 386
2:50	1 912	276 110	4 602	1 045	153 390	2 556
3:00	1 925	294 610	4 910	1 052	163 670	2 728
3:10	1 938	313 250	5 221	1 059	174 030	2 900
3:20	1 950	332 000	5 533	1 066	184 450	3 074
3:30	1 962	350 890	5 848	1 072	194 940	3 249
3:40	1 975	369 890	6 165	1 079	205 500	3 425
3:50	1 988	389 030	6 484	1 086	216 130	3 602
4:00	2 000	408 280	6 805	1 093	226 820	3 780
4:10	2 012	427 670	7 128	1 100	237 590	3 960
4:20	2 025	447 180	7 453	1 107	248 430	4 140
4:30	2 038	466 810	7 780	1 114	259 340	4 322
4:40	2 050	486 560	8 110	1 121	270 310	4 505
4:50	2 062	506 450	8 441	1 128	281 360	4 689
5:00	2 075	526 450	8 774	1 135	292 470	4 874
5:10	2 088	546 580	9 110	1 142	303 660	5 061
5:20	2 100	566 840	9 447	1 149	314 910	5 248
5:30	2 112	587 220	9 787	1 156	326 240	5 437
5:40	2 125	607 730	10 129	1 163	337 630	5 627
5:50	2 138	628 360	10 473	1 170	349 090	5 818
6:00	2 150	649 120	10 819	1 177	360 620	6 010
6:10	2 162	670 000	11 167	1 184	372 230	6 204
6:20	2 175	691 010	11 517	1 191	383 900	6 398
6:30	2 188	712 140	11 869	1 198	395 640	6 594
6:40	2 200	733 400	12 223	1 204	407 450	6 791
6:50	2 212	754 780	12 580	1 211	419 330	6 989
7:00	2 225	776 290	12 938	1 218	431 270	7 188
7:10	2 238	797 920	13 299	1 225	443 290	7 388
7:20	2 250	819 680	13 661	1 232	455 380	7 590
7:30	2 262	841 560	14 026	1 239	467 540	7 792
7:40	2 275	863 570	14 393	1 246	479 760	7 996
7:50	2 288	885 700	14 762	1 253	492 060	8 201
8:00	2 300	907 960	15 133	1 260	504 420	8 407

Standard Methods of

FIRE TESTS OF DOOR ASSEMBLIES[1]

ASTM Designation: E 152 – 58

(*Formerly Designated C 152 – 41*)

Adopted, 1958.[2]

This Standard of the Amreican Society for Testing Materials is issued under the fixed designation E 152; the final number indicates the year of original adoption as standard or, in the case of revision, the year of last revision.

Scope

1. (*a*) These methods of fire test are applicable to door assemblies of various materials and types of construction, for use in wall openings to retard the passage of fire.

(*b*) Tests made in conformity with these test methods will register performance during the test exposure; but such tests shall not be construed as determining suitability for use after exposure to fire.

(*c*) It is the intent that tests made in conformity with these test methods will develop data to enable regulatory bodies to determine the suitability of door assemblies for use in locations where fire resistance of a specified duration is required.

Control of Fire Tests

Time-Temperature Curve

2. The fire exposure of door assemblies shall be controlled to conform to the applicable portion of the standard time-temperature curve shown in Fig. 1. The points on the curve that determine its character are:

1000 F (538 C)	at 5 min
1300 F (704 C)	at 10 min
1550 F (843 C)	at 30 min
1700 F (927 C)	at 1 hr
1850 F (1010 C)	at 2 hr
2000 F (1093 C)	at 4 hr
2300 F (1260 C)	at 8 hr or over

For a closer definition of the time-temperature curve, see the Appendix.

Furnace Temperatures

3. (*a*) The temperatures of the test exposure shall be deemed to be the average temperature obtained from the readings of not less than nine thermocouples symmetrically disposed and distributed to show the temperature near all parts of the test assembly. The thermocouples shall be protected by sealed porcelain tubes having $\frac{3}{4}$ in. out-

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[1] Under the standardization procedure of the Society, these methods are under the jurisdiction of the ASTM Committee E-5 on Fire Tests of Materials and Construction.

[2] Prior to their present adoption as standard these methods were published as tentative from 1940 to 1941. They were adopted in 1941, and published as standard from 1941 to 1955 when they were revised and reverted to tentative. They were published as tentative from 1955 to 1958, being revised in 1956.

side diameter and $\frac{1}{8}$ in. wall thickness, or, as an alternate, in the case of base metal thermocouples, protected by $\frac{1}{2}$-in. wrought steel or wrought iron pipe of standard weight. The junction of the thermocouples shall be 6 in. from the exposed face of the test assembly or from the masonry in which the assembly is installed, during the entire test exposure.

(*b*) The temperatures shall be read at intervals not exceeding 5 min during the first 2 hr, and thereafter the intervals may be increased to not more than 10 min.

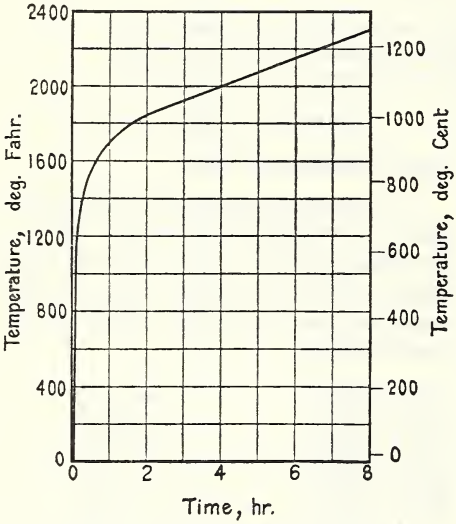

FIG. 1.—Time-Temperature Curve.

(*c*) The accuracy of the furnace control shall be such that the area under the time-temperature curve, obtained by averaging the results from the thermocouple readings, is within 10 per cent of the corresponding area under the standard time-temperature curve for fire tests of 1 hr or less duration, within 7.5 per cent for those over 1 hr and not more than 2 hr, and within 5 per cent for tests exceeding 2 hr in duration.

Unexposed Surface Temperatures

4. If unexposed surface temperatures are recorded, they shall be determined in the following manner:

(*a*) Unexposed surface temperatures shall be taken at not less than three points with at least one thermocouple in each 16 sq ft area of the door. Thermocouples shall not be located over reinforcements extending through the door, over vision panels, or nearer than 12 in. from the edge of the door.

(*b*) Unexposed surface temperatures shall be measured with thermocouples placed under flexible, oven-dry, felted asbestos pads 6 in. square, 0.4 in. in thickness, and weighing not less than 1.0 nor more than 1.4 lb per sq ft. The pads shall be held firmly against the surface of the door and fit closely about the thermocouples. The thermocouple leads shall be immersed under the pad for a distance of not less than $3\frac{1}{2}$ in. with the hot junction under the center of the pad. The thermocouple leads under the pads shall be not heavier than No. 18 B & S gage (0.04 in.) and shall be electrically insulated with heat-resistant and moisture-resistant coatings.

(*c*) Unexposed surface temperatures shall be read at the same intervals as used for the furnace temperatures in Section 3(*b*).

TEST ASSEMBLIES

Construction and Size

5. (*a*) The construction and size of the test door assembly, consisting of single doors or doors in pairs, shall be representative of that for which classification or rating is desired. The materials and construction of the door and frame, and the details of the installation, hardware, trim, finish and clearance or lap shall be recorded to assure positive identification or duplication in all respects.

(*b*) A sill shall be provided as part of the opening to be protected, except where such sill interferes with the operation of the door. The sill shall be of noncombustible material and project into the furnace approximately twice the thickness of the test door.

Mounting

6. (*a*) Swinging doors shall be mounted so as to open into the furnace chamber. Sliding and rolling doors shall be mounted on the exposed side of the opening in the wall closing the furnace chamber. The mounting of all doors shall be such that they fit snugly within the frame, against the wall surface or in guides, but such mounting shall not prevent free and easy operation of the test door.

(*b*) Clearances for swinging doors shall be as follows, with $\frac{1}{16}$-in. variation: $\frac{3}{32}$ in. at the top, $\frac{3}{16}$ in. at the bottom, and $\frac{3}{32}$ in. between the door and hinge and lock jams.

CONDUCT OF TESTS

Time of Testing

7. Masonry settings shall be allowed to dry at least 3 days before tests are made.

Fire Endurance Test

8. (*a*) The pressure in the furnace chamber shall be maintained as nearly equal to the atmospheric pressure as possible.

(*b*) The test shall be continued until the exposure period of the desired classification or rating is reached unless the conditions of acceptance set forth in Section 11 are exceeded in a shorter period.

Hose Stream Test

9. (*a*) Immediately following the fire endurance test, the test assembly shall be subjected to the impact, erosion, and cooling effects of a hose stream directed first at the middle and then at all parts of the exposed surface, changes in direction being made slowly.

(*b*) The hose stream shall be delivered through a $2\frac{1}{2}$-in. hose discharging through a National Standard Playpipe of corresponding size equipped with a $1\frac{1}{8}$-in. discharge tip of the standard-taper smooth-bore pattern without shoulder at the orifice. The water pressure at the base of the nozzle and duration of application in minutes per 100 sq ft of exposed area shall be as prescribed in Table I.

(*c*) The tip of the nozzle shall be located 20 ft from and on a line normal to the center of the test door. If impossible to be so located, the nozzle may be on a line deviating not to exceed 30 deg from the line normal to the center of the test door. When so located the distance from the center shall be less than 20 ft by an amount equal to 1 ft for each 10 deg of deviation from the normal.

TABLE I.—WATER PRESSURE AT BASE OF NOZZLE AND DURATION OF APPLICATION.

Desired Rating	Water Pressure at Base of Nozzle, psi	Duration of Application, min per 100 sq ft exposed area
3 hr	45	5
$1\frac{1}{2}$ hr and over, if less than 3 hr	30	$2\frac{1}{2}$
1 hr and over, if less than $1\frac{1}{2}$ hr	30	$1\frac{1}{2}$
Less than 1 hr	30	1

Report

10. Results shall be reported in accordance with the performance in the tests prescribed in these test methods. The report shall show the performance under the desired exposure period chosen from the following; 20 min, 30 min, $\frac{3}{4}$ hr, 1 hr, $1\frac{1}{2}$ hr, or 3 hr. The report shall include the temperature measurements of the furnace and, if determined, of the unexposed side of the test assembly. It shall also contain a record of all observations having a bearing on the performance of the test assembly.

CONDITIONS OF ACCEPTANCE

Conditions of Acceptance

11. A door assembly shall be considered as meeting the requirements for acceptable performance when it remains in the opening during the fire endurance test and hose stream test within the following limitations:

(*a*) The movement of swing doors shall not permit any portion of the edges to move from the original position more than the thickness of the door, during the first half of the classification period, nor more than 1½ times the thickness during the entire classification period, and as a result of the hose stream.

(*b*) An assembly consisting of a pair of swinging doors shall not separate more than ¾ in. or equal to the throw of the latch bolt at the latch location.

(*c*) An assembly consisting of a single swinging door shall not separate more than ½ in. at the latch location.

(*d*) Doors mounted on the face of the wall shall not move from the wall sufficient to develop a separation equivalent to the thickness of the edge of the door at the point of separation.

(*e*) Doors mounted in guides shall not release from guides and guides shall not loosen from fastenings.

(*f*) The test assembly shall have withstood the fire endurance test and hose-stream test, without developing openings anywhere through the assembly, except that small portions of glass dislodged by the hose stream shall not be considered a weakness.

(See Appendix, p. 389.)

APPENDIX

TABLE I1.—STANDARD TIME-TEMPERATURE CURVE FOR CONTROL OF FIRE TESTS.

Time	Temperature, deg Fahr	Area Above 68 F Base		Temperature, deg Cent	Area Above 20 C Base	
hr:min		deg Fahr-min	deg Fahr-hr		deg Cent-min	deg Cent-hr
0:00	68	00	0	20	00	0
0:05	1 000	2 330	39	538	1 290	22
0:10	1 300	7 740	129	704	4 300	72
0:15	1 399	14 150	236	760	7 860	131
0:20	1 462	20 970	350	795	11 650	194
0:25	1 510	28 050	468	821	15 590	260
0:30	1 550	35 360	589	843	19 650	328
0:35	1 584	42 860	714	862	23 810	397
0:40	1 613	50 510	842	878	28 060	468
0:45	1 638	58 300	971	892	32 390	540
0:50	1 661	66 200	1 103	905	36 780	613
0:55	1 681	74 220	1 237	916	41 230	687
1:00	1 700	82 330	1 372	927	45 740	762
1:05	1 718	90 540	1 509	937	50 300	838
1:10	1 735	98 830	1 647	946	54 910	915
1:15	1 750	107 200	1 787	955	59 560	993
1:20	1 765	115 650	1 928	963	64 250	1 071
1:25	1 779	124 180	2 070	971	68 990	1 150
1:30	1 792	132 760	2 213	978	73 760	1 229
1:35	1 804	141 420	2 357	985	78 560	1 309
1:40	1 815	150 120	2 502	991	83 400	1 390
1:45	1 826	158 890	2 648	996	88 280	1 471
1:50	1 835	167 700	2 795	1 001	93 170	1 553
1:55	1 843	176 550	2 942	1 006	98 080	1 635
2:00	1 850	185 440	3 091	1 010	103 020	1 717
2:10	1 862	203 330	3 389	1 017	112 960	1 882
2:20	1 875	221 330	3 689	1 024	122 960	2 049
2:30	1 888	239 470	3 991	1 031	133 040	2 217
2:40	1 900	257 720	4 295	1 038	143 180	2 386
2:50	1 912	276 110	4 602	1 045	153 390	2 556
3:00	1 925	294 610	4 910	1 052	163 670	2 728
3:10	1 938	313 250	5 221	1 059	174 030	2 900
3:20	1 950	332 000	5 533	1 066	184 450	3 074
3:30	1 962	350 890	5 848	1 072	194 940	3 249
3:40	1 975	369 890	6 165	1 079	205 500	3 425
3:50	1 988	389 030	6 484	1 086	216 130	3 602
4:00	2 000	408 280	6 805	1 093	226 820	3 780
4:10	2 012	427 670	7 128	1 100	237 590	3 960
4:20	2 025	447 180	7 453	1 107	248 430	4 140
4:30	2 038	466 810	7 780	1 114	259 340	4 322
4:40	2 050	486 560	8 110	1 121	270 310	4 505
4:50	2 062	506 450	8 441	1 128	281 360	4 689
5:00	2 075	526 450	8 774	1 135	292 470	4 874
5:10	2 088	546 580	9 110	1 142	303 660	5 061
5:20	2 100	566 840	9 447	1 149	314 910	5 248
5:30	2 112	587 220	9 787	1 156	326 240	5 437
5:40	2 125	607 730	10 129	1 163	337 630	5 627
5:50	2 138	628 360	10 473	1 170	349 090	5 818
6:00	2 150	649 120	10 819	1 177	360 620	6 010
6:10	2 162	670 000	11 167	1 184	372 230	6 204
6:20	2 175	691 010	11 517	1 191	383 900	6 398
6:30	2 188	712 140	11 869	1 198	395 640	6 594
6:40	2 200	733 400	12 223	1 204	407 450	6 791
6:50	2 212	754 780	12 580	1 211	419 330	6 989
7:00	2 225	776 290	12 938	1 218	431 270	7 188
7:10	2 238	797 920	13 299	1 225	443 290	7 388
7:20	2 250	819 680	13 661	1 232	455 380	7 590
7:30	2 262	841 560	14 026	1 239	467 540	7 792
7:40	2 275	863 570	14 393	1 246	479 760	7 996
7:50	2 288	885 700	14 762	1 253	492 060	8 201
8:00	2 300	907 960	15 133	1 260	504 420	8 407

Tentative Method of
FIRE HAZARD CLASSIFICATION OF BUILDING MATERIALS[1]

ASTM Designation: E 84 – 50 T

ISSUED, 1950.[2]

This Tentative Method has been approved by the sponsoring committee and accepted by the Society in accordance with established procedures, for use pending adoption as standard. Suggestions for revisions should be addressed to the Society at 1916 Race St., Philadelphia 3, Pa.

Scope

1. (*a*) This method of fire hazard classification is applicable to any type of building material that by its own structural qualities, or by the manner in which it is applied, is capable of supporting itself in position. The purpose is to determine the comparative fire hazard classification of the material under test by evaluating the rate of flame spread over its surface, rate of combustion and heat generated, and the smoke density developed when attacked by an exposing fire.

(*b*) It is the intent that classification shall register performance during the period of exposure, and shall not be construed as having determined suitability for use after the test exposure.

(*c*) This method does not establish ratings or standards of performance for specific uses, as these depend upon service requirements.

NOTE.—Reference may be made to the Standard Methods of Fire Tests of Building Construction and Materials (ASTM Designation: E 119)[3] for procedures for determining the performance of building constructions and materials when incorporated into a test structure and subjected to a standard exposing fire of controlled extent and severity.

Test Equipment

2. The test equipment may be located at any place where all the necessary facilities for properly conducting the test are provided.

NOTE.—Reference may be made to the Underwriters Laboratory, Inc. "Bulletin of Research No. 32," September, 1944, for photographs and diagrams of equipment and fire hazard classifications of various representative materials.

Fire Test Chamber

3. (*a*) The fire test chamber shall consist of a duct having an inside width of 17 in. and a length of 25 ft. The sides and base of the duct shall be insulated and of noncombustible material, one side being provided with numerous observation ports. The removable top or roof shall consist of an insulated structural framework 25 ft. long and 20 in. wide formed into a flat noncombustible surface, which shall be fitted to the top of the duct in such a manner as to preclude

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[1] Under the standardization procedure of the Society, this method is under the jurisdiction of the ASTM Committee E-5 on Fire Tests of Materials and Construction.

[2] Accepted by the Society at the Annual Meeting, June, 1950.

[3] See p. 374.

air leakage into the test structure around its edges. The material to be tested shall be applied to the lower face of this framework in the same manner as it will be applied in actual use.

(*b*) One end of the chamber, designated as the "fire end," shall be provided with gas burners delivering flames vertically upward against the surface of the test sample. An adjustable opening and a tube for attaching a draft gage shall be provided at this end to permit the passage and recording of the desired amount of air.

(*c*) The other end of the chamber, designated as the "vent end," shall be provided with a vent pipe fitted with a manually controlled damper for regulating the velocity of air travel. Movement of air may be produced by induced draft or by a variable-speed suction fan. A light source shall be mounted on the vent pipe so as to direct a beam of light along the vertical diameter of the pipe. The beam of light shall be received on a photoelectric cell, which in turn shall be connected to a suitable microammeter. The cell shall be of a type whose current output is directly proportional to the light intensity.

(*d*) A thermocouple shall be inserted through the floor of the duct, the tip being located 1 in. from the exposed surface of the sample and 24 ft. distant from the fire end of the sample.

Test Samples

4. (*a*) The test sample shall be truly representative of the materials for which classification is desired, and assembled under conditions representative of practice as practically applied in building construction and operation. The physical properties of the materials or ingredients, or both, used in the test sample shall be determined and recorded.

(*b*) The test sample shall be conditioned before test until constant conditions have been reached at a temperature of 70 ± 5 F., and at a relative humidity of 35 to 40 per cent.

(*c*) The test sample shall be attached to the removable top of the test structure in the same manner and using the same materials for attachment as are recommended in the manufacturer's instructions for application and use.

Test Procedure

5. (*a*) The removable top of the test chamber, with the sample attached to its lower face, shall be placed in position and all joints sealed against the infiltration of air. The draft regulating damper shall be adjusted to establish an air velocity of 200 ± 5 fpm., measured in the full cross-section of the duct at the vent end. The corresponding reading on the draft gage shall be noted, and this reading shall be maintained throughout the test by regulation of the damper. The air supply shall be maintained at 70 ± 5 F., and relative humidity at between 35 and 40 per cent.

(*b*) The igniting flame shall be lighted and adjusted as follows: The flame shall be such that under the controlled conditions described in Paragraph (*a*), a test sample of select Grade A red oak[4] will become involved in flame throughout its entire length in 6 min. (Note). The test shall be continued for a 10-min. period unless the sample is completely consumed in the fire area before that time, in which case the test shall be ended after complete combustion occurs.

NOTE.—This will require the equivalent of a test flame the full width of the duct, about 4½ ft. long, and burning approximately 8 cu. ft. of 800-btu. gas per min.

(*c*) When the test is ended the gas supply shall be shut off, smoldering and other conditions within the test duct observed, and the sample removed for further examination.

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[4] Select red oak was chosen for the purpose because, among other reasons, the term denotes a fairly uniform material throughout the United States, whereas many other designations have a purely local significance.

Calibration of Test Equipment

6. (*a*) With the test equipment adjusted as above described, a series of tests shall be made, using asbestos-cement board as the sample. Observations shall be made each 15 sec. of the length of spread of flame (which will be that of the test flame only), of the temperatures recorded by the thermocouple at the 24-ft. location (which will record the temperatures developed by the test flame only), and of the microammeter readings (which will record the reduced clear beam reading caused by the products of combustion of the test flame only).

(*b*) The three sets of readings shall be separately plotted on suitable coordinate paper and shall be considered as representing a classification of *zero* because the sample contributes neither to spread of fire, to heat of combustion, nor generation of smoke.

(*c*) Following establishment of the zero classification, similar tests shall be conducted on samples of select Grade A red oak, and the corresponding results plotted. These results shall be considered as representing a classification of *100*.

Classification

7. (*a*) The flame spread classification shall be determined by comparing the rate of time in which flame reaches the far end of the sample, if it does, with that established for red oak. If flame travels only part way of the sample, then ceases to continue or recedes, the comparison shall be made on the ratio of the distance traveled, measured from the end of the igniting flame to the extreme flame travel on the sample.

Note.—If flame reaches the end of the sample in 3 min. as compared to 6 min. for red oak, the classification is 200. If flame extends one half the distance from the end of the test flame to the end of the sample, then ceases to advance or recedes, the classification is 50.

(*b*) The test results for heat and smoke shall be plotted, using the same coordinates, and comparison of the areas under the respective curves will establish a numerical classification by which the performance of the material may be compared with that of asbestos-cement board and select Grade A red oak which have been arbitarily established as zero and 100, respectively.

Analysis of Products of Combustion

8. Although not a part of this procedure, products of combustion may be drawn from the test duct during the progress of the test for chemical analysis to determine degree of toxicity, irritability, or other characteristics that might be of concern considering the intended use of the material undergoing test.

Tentative Method of Test for

DEFINING NONCOMBUSTIBILITY OF BUILDING MATERIALS[1]

ASTM Designation: E 136 - 58 T

ISSUED, 1958.[2]

This Tentative Method has been approved by the sponsoring committee and accepted by the Society in accordance with established procedures, for use pending adoption as standard. Suggestions for revisions should be addressed to the Society at 1916 Race St., Philadelphia 3, Pa.

Scope

1. This method of test describes a procedure for the determination of noncombustibility of elementary materials of which building materials are composed, to indicate those materials which do not act to aid combustion or add appreciable heat to an ambient fire. It is not intended to apply to laminated or coated materials.

Definition

2. *Noncombustible.*—A material shall be classed as noncombustible if it meets the requirements of the test procedure described in these methods.

Apparatus

3. The apparatus, as shown in Fig. 1, shall consist primarily of the following:

(*a*) *Refractory Tubes.*—Two 10-in. long, concentric, refractory tubes, 3 and 4 in. in inside diameter, with axes vertical, and with heat applied by electric heating coils outside of the larger tube. A controlled flow of air is admitted tangentially near the top of the annular space between the tubes and passes to the bottom of the inner tube. The outer tube rests on a refractory bottom and the inner tube rests on three spacer blocks so as to afford a total opening under the inner tube equal to or greater than that of the annular space. The refractory bottom plate has a removable plug for cleaning.

(*b*) *Transparent Cover.*—A transparent cover of heat-resisting glass or other transparent material shall be provided over the top of the inner tube with a 1-in. square opening over the axis of the tubes. This cover may be in two movable parts.

(*c*) *Thermocouples* or other temperature-measuring devices, preferably automatically recording, shall be provided, one for the air in the lower part of the inner tube, another on the specimen in the approximate center of the space, and a third within the interior of the specimen. A fourth thermocouple may be provided, if desired, in the region of the heating coils for better regulation of the temperature of the air in the furnace space.

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[1] Under the standardization procedure of the Society, this method is under the jurisdiction of the ASTM Committee E-5 on Fire Tests of Materials and Construction.

[2] Accepted by the Society at the Annual Meeting, June, 1958.

Published first as information in the ASTM BULLETIN, No. 220, February, 1957, p. 33.

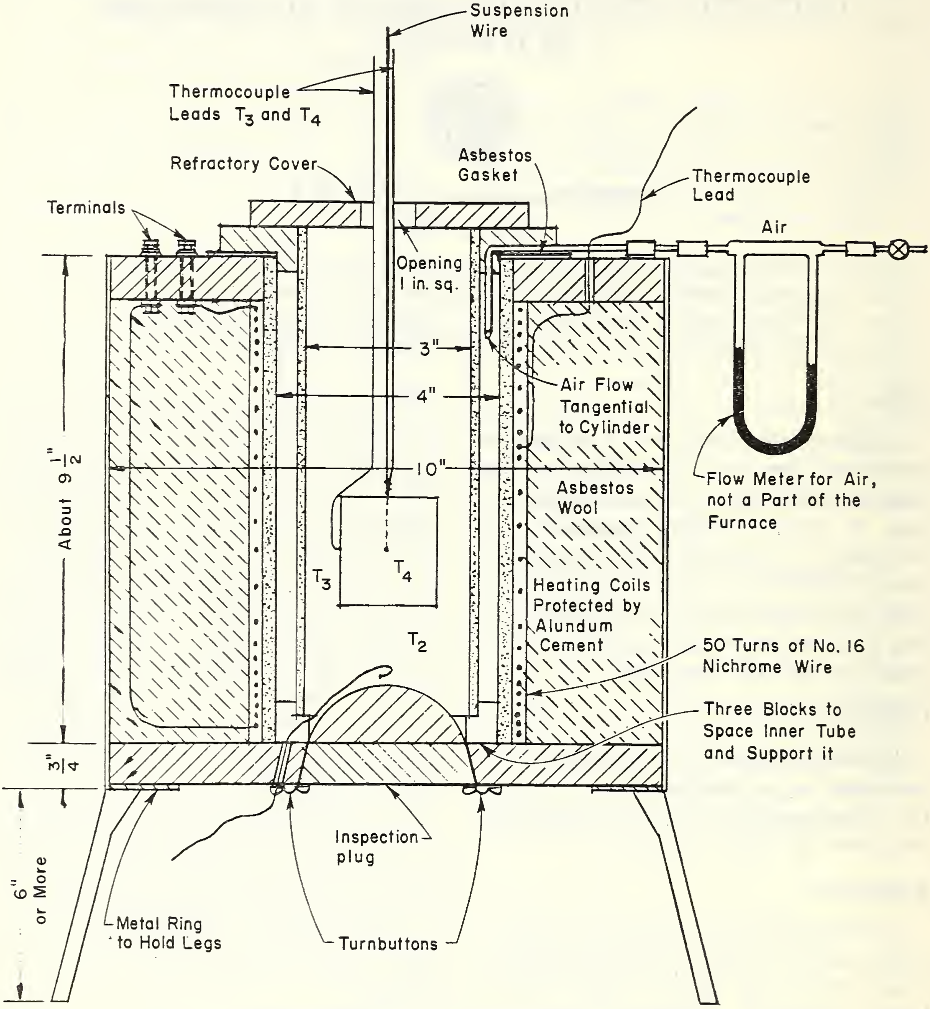
Suspension Wire
Thermocouple Leads T_3 and T_4
Refractory Cover
Terminals
Asbestos Gasket
Thermocouple Lead
Air
Opening 1 in. sq.
3"
4"
10"
About $9\frac{1}{2}$"
Air Flow Tangential to Cylinder
Asbestos Wool
Flow Meter for Air, not a Part of the Furnace
T_3
T_4
T_2
Heating Coils Protected by Alundum Cement
50 Turns of No. 16 Nichrome Wire
Three Blocks to Space Inner Tube and Support it
$\frac{3}{4}$"
Inspection plug
6" or More
Metal Ring to Hold Legs
Turnbuttons

FIG. 1.—Cross-Section of Furnace Assembly.

Test Specimens

4. (*a*) All test specimens shall be 1.5 in. wide by 1.5 in. thick in cross-section perpendicular to the air flow in the furnace, and 2.0 in. long, with tolerances on the dimensions of ±0.1 in. The specimens shall be dried at 140 ± 5 F for not less than 24 nor more than 48 hr before being tested.

(*b*) Specimens in granular or powder form may be contained in thin-wall, open-top vessels of inert materials whose outside dimensions conform to the specimen shape and maximum size specified in Paragraph (*a*). These vessels may have solid walls or be of mesh.

(*c*) Not less than four identical specimens shall be tested to permit a material to meet the requirements of this test.

Procedure

5. (*a*) Prepare the furnace by bringing the temperature, T_2 (in the tube under the specimen, Fig. 1) of the air in the furnace tube to 1382 ± 10 F, maintaining the furnace setting long enough to ascertain that it will remain at constant temperature in the unloaded furnace for at least 15 min while air passes at a velocity of 10 ft per min ± 20 per cent past a loaded specimen in the tube, computed on the basis of air supply and velocity at room temperature and pressure.

(*b*) As rapidly as possible, insert the test specimen into the furnace, with thermocouple T_3 attached to the side surface of the specimen and thermocouple T_4 inserted from the top of the specimen to its approximate volumetric center. Close the top cover to the 1-sq in. opening immediately after insertion of the specimen. If readings are to be made manually, make them as often as possible, particularly for thermocouples T_3 and T_4 at intervals not less than once per minute for the first 5 min, and as often afterwards as necessary to produce a smooth curve. Do not change the regulation of the current through the heating coils and the air flow during the test.

(*c*) Continue the test until the temperatures at thermocouples T_3 and T_4 have reached maxima, or until it is clearly evident that the specimen does not pass this test.

(*d*) Throughout the test make and record visual observations on the specimens, noting quality, quantity, or intensity and duration of flaming or smoking, or both, and change of state.

(*e*) The results of the four specimens tested shall be averaged.

Interpretation of Results

6. Materials subjected to the test described in this method shall be reported as noncombustible if for three or more of the four specimens tested, the recorded temperatures of the surface or interior thermocouples do not at any time during the test rise to more than 54 F (30 C) above the furnace air temperature at the beginning of the test, and if there is no flaming from the specimen after the first 30 sec.

General Methods of Testing

APPROVED AS
AMERICAN STANDARD
BY THE AMERICAN STANDARDS ASSOCIATIO
ASA NO.: A37.2-1951
UDC 665.45:620.1

AMERICAN ASSOCIATION STATE
HIGHWAY OFFICIALS STANDARD
A.A.S.H.O . NO.: T50

Standard Method of
FLOAT TEST FOR BITUMINOUS MATERIALS[1]

ASTM Designation: D 139 – 49

Adopted, 1927; Revised, 1949.[2]

Reapproved in 1958 Without Change.

This Standard of the American Society for Testing Materials is issued under the fixed designation D 139; the final number indicates the year of original adoption as standard or, in the case of revision, the year of last revision.

Scope

1. This method covers the float test for bituminous materials.

Apparatus

2. (*a*) *Float.*—The float (Fig. 1) shall be made of aluminum or aluminum alloy and shall be in accordance with the following requirements:

	Min	Normal	Max
Weight of float, g...	37.70	37.90	38.10
Total height of float, mm............	34.0	35.0	36.0
Height of rim above lower side of shoulder, mm....	26.5	27.0	27.5
Thickness of shoulder, mm.........	1.3	1.4	1.5
Diameter of opening, mm.........	11.0	11.1	11.2

(*b*) *Collar.*— The collar (Fig. 1) shall be made of brass and shall be in accordance with the following requirements:

	Min	Normal	Max
Weight of collar, g..	9.60	9.80	10.00
Over-all height of collar, mm.......	22.3	22.5	22.7
Inside diameter at bottom, mm.....	12.72	12.82	12.92
Inside diameter at top, mm.........	9.65	9.70	9.75

The top of the collar shall screw up tightly against the lower side of the shoulder.

(*c*) *Calibration of Assembly.*—The assembled float and collar, with the collar filled flush with the bottom and weighted to a total weight of 53.2 g, shall float upon water with the rim 8.5 ± 1.5 mm above the surface of the water. This adjustment of the total weight of the assembly is for the purpose only of calibrating the depth of immersion in the testing bath.

(*d*) *Thermometer.*—An ASTM Low Softening Point Thermometer, graduated in either Centigrade or Fahrenheit degrees as specified, having a range of −2 to +80 C or +30 to +180 F and conforming to the requirements for thermometer 15C – 39 or 15F – 39, respectively, as prescribed in ASTM Specifications E 1.[3]

(*e*) *Testing Bath.*—A water bath at least 185 mm in internal diameter and containing water at least 185 mm in depth. The height of the container above the surface of the water shall be at least 100 mm.

(*f*) *Water Bath at 5 C.*—A water bath

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[1] Under the standardization procedure of the Society, this method is under the jurisdiction of the ASTM Committee D-4 on Road and Paving Materials.

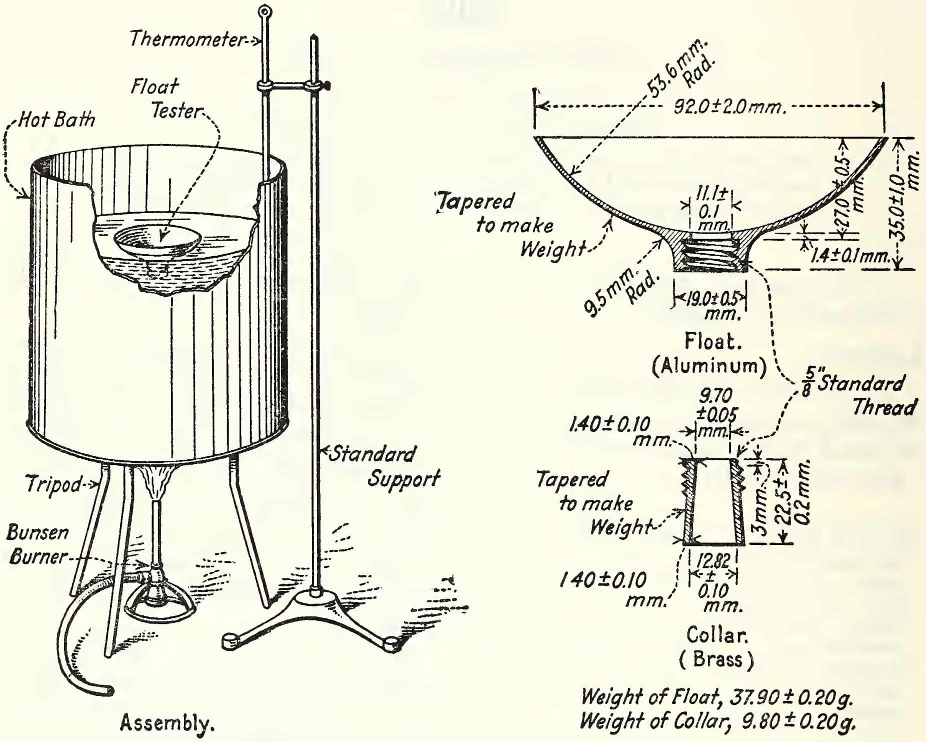
[2] Prior to adoption as standard, this method was published as tentative from 1922 to 1927, being revised in 1923, 1924, 1925, and 1927.

[3] 1958 Book of ASTM Standards, Part 7.

of suitable dimensions maintained at 5.0 ± 1.0 C, which may be accomplished by means of melting ice.

Procedure

3. (*a*) Place the brass collar with the smaller end on a brass plate which has been previously amalgamated with mercury by first rubbing it with a dilute solution of mercuric chloride or nitrate, and then with mercury.



Weight of Float, 37.90 ± 0.20 g.
Weight of Collar, 9.80 ± 0.20 g.

FIG. 1.—Float Test Apparatus.

(*b*) The sample shall be completely melted at the lowest possible temperature that will bring it to a sufficiently fluid condition for easy pouring, excepting creosote-oil residues, which shall be mixed and poured at a temperature of 100 to 125 C. Stir the sample thoroughly until it is homogeneous and free from air bubbles. Then pour it into the collar in any convenient manner until slightly more than level with the top.

(*c*) *Asphalt and Asphalt Products.*—Cool asphalt and asphalt products to room temperature for 15 to 60 min, then place them for 5 min in the water bath at 5 C, after which trim the surplus material flush with the top of the collar by means of a spatula or steel knife that has been slightly heated. Then place the collar and plate in the water bath at 5 C and leave them in this bath for not less than 15 nor more than 30 min.

(*d*) *Tar Products.*—Immediately immerse tar products for 5 min in the water bath at 5 C, after which trim the surplus material flush with the top of the collar by means of a spatula or steel knife that has been slightly heated. Then place the collar and plate in the water bath at 5 C, and leave them in this bath for not less than 15 nor more than 30 min.

(*e*) Heat the water in the testing bath to the temperature at which the test is to be made. This temperature shall be accurately maintained without stirring, and shall at no time throughout the test be allowed to vary more than 0.5 C from the temperature specified. The temperature shall be determined by immersing the thermometer with the bottom of the bulb at a depth of 40 ± 2 mm below the water surface.

(*f*) After the material to be tested has been kept in the water bath at 5 C for not less than 15 nor more than 30 min remove the collar with its contents from the plate and screw into the aluminum float. Completely immerse the assembly for 1 min in the water bath at 5 C. Then remove the water from the inside of the float and immediately float the assembly on the testing bath. Lateral drift of the assembly shall be permitted, but no spinning motion shall be intentionally imparted thereto. As the plug of material becomes warm and fluid, it is forced upward and out of the collar until the water gains entrance into the saucer and causes it to sink.

(*g*) The time, in seconds, between placing the apparatus on the water and the water breaking through the material shall be determined by means of a stop watch, and shall be taken as a measure of the consistency of the material under examination.

Precautions

4. (*a*) Special precautions should be taken to insure that the collar fits tightly into the float and to see that there is no seepage of water between the collar and float during the test.

(*b*) Owing to possible danger to health if mercury is handled carelessly, the following rules should be observed at all times:

(*1*) Store the mercury in a closed jug in a cool place.

(*2*) Strictly avoid spilling any mercury.

(*3*) Remove mercury vapors by working under a suitable hood with good ventilation.

(*4*) Keep amalgamated brass plates and other apparatus at not above normal room temperature.

APPROVED AS
AMERICAN STANDARD
BY THE AMERICAN STANDARDS ASSOCIATION
ASA NO.: Z11.26-1958
UDC 665.5:620.1

Standard Method of Test for
DISTILLATION OF GAS OIL AND SIMILAR DISTILLATE FUEL OILS[1]

ASTM Designation: D 158 - 54

ADOPTED, 1928; REVISED, 1938, 1941, 1952, 1953, 1954.[2]

This Standard of the American Society for Testing Materials is issued under the fixed designation D 158; the final number indicates the year of original adoption as standard or, in the case of revision, the year of last revision.

Scope

1. This method of test is intended for use in the distillation of liquid petroleum distillates having viscosities intermediate between kerosine and lubricating oil.

Apparatus

2. The apparatus shall consist of the following:

(*a*) *Flask.*—A Saybolt distilling flask conforming to the following dimensions and permissible variations:

	Centimeters	Inches	Permissible Variations	
			Centimeters	Inches
Diameter of bulb, outside	8.57	3.37	±0.3	±0.12
Diameter of neck, inside	1.50	0.59	±0.1	±0.04
Over-all length, neck plus bulb	21.50	8.46	±0.3	±0.12
Length of vapor tube	10.0	3.94	±0.3	±0.12
Diameter of vapor tube, outside	0.60	0.24	±0.05	±0.02
Diameter of vapor tube, inside	0.40	0.16	±0.05	±0.02
Thickness of vapor tube wall	0.10	0.04	±0.015	±0.006

The center of the vapor tube shall be 6.5 ± 0.3 cm, (2.56 ± 0.12 in.) below the top of the neck. The tube shall be approximately in the middle of the neck and set at an angle of 75 ± 3 deg with the vertical.

(*b*) *Condenser.*—A condenser[3] $\frac{9}{16}$ in. (14.29 mm) in outside diameter, with 0.031- to 0.036-in. wall thickness, made of seamless brass tubing, 22 in. (55.88 cm) in length. It shall be set so that approximately 15.5 in. (39.4 cm) of the tube will be in contact with the cooling medium contained in the condenser jacket, subsequently described, with about 2 in. outside the cooling bath at the upper end, and 4.5 in. outside the cooling bath at the lower end. The length of tube projecting at the upper end shall be straight and shall be set at an angle of 75 deg with the vertical. The section of the tube inside the cooling bath may be either straight or bent in any suitable continuous, smooth curve. The average gradient shall be 0.26 in. per linear inch of condenser tube (sine of angle of 15 deg) and no section of the immersed portion of the condenser tube shall have a gradient less than 0.24 in. nor more than 0.28 in. per linear inch of tube. The projecting lower portion of the condenser tube shall be curved downward for a length of 3 in. (7.62 cm) and slightly backward so as to insure contact with the wall of the receiving graduate at a point approximately 1 to 1¼ in. (2.54 to 3.18 cm) below the top of the graduate when it is in position to receive the distillate. The lower end of the condenser tube shall be cut off at an acute angle. The capacity of the cooling bath shall be not less than 340 cu in. (5.55 liters) of cooling medium. The arrangement of the tube in the cooling bath shall be such that its center line shall be not less than 1¼ in. below the plane of the top of the bath at its point of entrance and not less than ¾ in. above the floor of the bath at its exit. Clearances between the condenser tube and the walls of the bath shall be at least ½ in. except for the sections adjacent to the points of entrance and exit. Multiple installations are permissible, provided they conform to the dimensional requirements and the capacity of the bath is not less than 340 cu in. per tube.

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[1] Under the standardization procedure of the Society, this method is under the jurisdiction of the ASTM Committee D-2 on Petroleum Products and Lubricants.

[2] Prior to adoption as standard, this method was published as tentative from 1923 to 1928, being revised in 1925.

In 1954, minor changes in apparatus were made in Section 2 (*a*), (*c*), (*d*), and (*f*).

[3] A condenser and shield conforming to these requirements are illustrated in the Standard Method of Test for Distillation of Gasoline, Naphtha, Kerosine, and Similar Petroleum Products (ASTM Designation: D 86), see p. 8.

(*c*) *Shield.*—Two types of shields can be used, as follows:

Type 1 Shield.—A shield[3] 19 in. high, 11 in. long and 8 in. wide, made of sheet metal approximately No. 22 gage, with a door on one narrow side, two openings 1 in. in diameter equally spaced in each of the two narrow sides, and with a slot cut in one side for the vapor tube. The centers of these four openings shall be 8½ in. below the top of the shield. There shall be three ½-in. holes in each of the four sides with their centers 1 in. above the base of the shield.

Type 2 Shield.—A shield 17½ in. high, 8 in. long and 8 in. wide made of sheet metal of approximately No. 22 gage, with window on front side. Open bottom of shield spaced approximately 2 in. from base of unit. Rear of shield to have elliptical hole for vapor tube. A flask adjusting knob located on the front of the shield for adjusting the flask support. Also heat adjusting indicating dial to provide stepless heat control when electric heater is used. All mechanism built into bottom portion of shield.

(*d*) *Flask Support and Ceramic or Asbestos Boards.*—A ring support of the ordinary laboratory type, 4 in. or larger in diameter, supported on a stand inside the shield, or a flask support platform that is adjustable from the outside of the shield may be used. Two ceramic or hard asbestos boards, the first having a hole 2¾ in. in diameter in the center and the thickness of the board at the 2¾-in. diameter opening shall be ⅛ to ¼ in.; the second board to fit tightly inside the shield with an opening 3 to 4 in. in diameter, concentric with the flask support. These shall be arranged as follows: the second board shall be placed on the support, and the first or smaller board on top so it may be moved in accordance with the directions for placing the distillation flask. Direct heat shall be applied to the flask only through the 2¾-in. diameter opening in the first board.

(*e*) *Gas Burner.*—A burner so constructed that sufficient heat can be obtained to distill the product at the uniform rate specified in Section 4. The flame shall never be so large that it spreads over a circle of diameter greater than 4½ in. (11.43 cm) on the under surface of the asbestos board. A sensitive regulating valve and gas pressure governor are desirable adjuncts, as they give complete control of heating.

(*f*) *Electric Heater.*—An electric heater may be used instead of a gas burner and shall be capable of bringing over the first drop within the time specified in Section 4 (*a*) when started cold, and of continuing the distillation at a uniform rate. (A heater unit of low-heat capacity, adjustable from 0 to 750 w, has been found satisfactory). The electric heater shall be fitted with a ceramic or hard asbestos board top having a hole 2¾ in. in diameter in the center, and the thickness of the board at the 2¾-in. in diameter opening shall be ⅛ to ¼ in. When an electric heater is employed, the portion of the shield above the board shall be the same as with the gas burner, but the part below the board may be omitted.

(*g*) *Thermometer.*—An ASTM High Distillation Thermometer, total immersion, graduated in either Centigrade or Fahrenheit degrees as specified, having a range of −2 to 400 C or 30 to 760 F and conforming to the requirements for thermometer 8C or 8F, respectively, as prescribed in the Standard Specifications for ASTM Thermometers (ASTM Designation: E 1).[4]

NOTE 1.—Whenever thermometers complying with ASTM requirements are not available, thermometers complying with the requirements for The Institute of Petroleum Thermometer "IP 6C High Distillation" may be used, provided calibration corrections are used in temperature ranges where IP requirements for scale accuracy are less stringent than those of ASTM.

(*h*) *Graduate for Sample.*—A graduate or pipete graduated to deliver 200 ± 1.0 ml, for measuring the sample to be tested.

(*i*) *Graduates for Fractions Taken on Temperature Basis.*—Graduates of the cylindrical type, of uniform diameter, with a pressed or molded base and a lipped top. They shall be graduated to contain 100 ml and the graduated portion shall be not less than 7 in. (17.78 cm) nor more than 8 in. (20.32 cm) in length. They shall be graduated in single milliliters and each fifth mark shall be distinguished by a longer line. They shall be numbered from the bottom at intervals of 10 ml. The over-all height of the graduates shall be not less than 9¾ in. (24.8 cm) nor more than 10¼ in. (26.0 cm). The graduations shall not be in error by more than 1 ml at any point on the scale.

(*j*) *Graduates for 10 per cent Fractions.*—Graduates of the cylindrical type, of uniform diameter, with a pressed or molded base and a lipped top. They shall be graduated to contain 25 ml and the graduated portion shall be not less than 3¼ in. (8.25 cm) nor more than 3¾ in. (9.52 cm) in length. They shall be graduated in half milliliters and each tenth mark (indicating multiples of 5 ml) shall be distinguished by a longer line. They shall be numbered from the bottom at intervals of 5 ml. The over-all height of the graduates shall be not less than 5⅜ in. (13.65 cm) nor more than 5⅝ in. (14.29 cm). The graduations shall not be in error by more than 0.25 ml at any point on the scale.

Preparation of Apparatus

3. (*a*) Provision shall be made for circulating water through the condenser.

(*b*) Swab the condenser tube to remove any liquid remaining from the previous test. A piece of soft, lint-free cloth attached to a cord or copper wire may be used for this purpose.

(*c*) Place a volume of water-free oil equivalent to 200 ml at 55 to 65 F (12.8 to 18.3 C) in the flask.

(*d*) Fit the thermometer, provided with a cork, tightly into the flask so that it will be in the middle of the neck and so that the lower end of the capillary tube is on a level with the inside of the bottom of the vapor outlet tube at its junction with the neck of the flask.

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[4] 1958 Book of ASTM Standards, Part 7.

(*e*) Place the charged flask over the $2\frac{3}{4}$-in. (6.99-cm) opening in the asbestos board with the vapor outlet tube inserted into the condenser tube. A tight connection may be made by means of a cork through which the vapor tube passes. Adjust the position of the flask so that the vapor tube extends into the condenser tube not less than 1 in. (2.54 cm) nor more than 2 in. (5.08 cm).

(*f*) Place a clean, dry graduated cylinder (see Section 2 (*i*) and (*j*)) at the outlet of the condenser tube in such position that the condenser tube shall extend into the graduate approximately 1 in. (2.54 cm) but not below the upper graduation mark.

Procedure

4. (*a*) When everything is in readiness, circulate water through the condenser bath at such a rate that the water overflowing the condenser shall be at a temperature of 90 to 100 F (32.2 to 37.8 C). Apply heat to the contents of the flask at a uniform rate, so regulated that the first drop of condensate falls from the condenser in not less than 10 nor more than 15 min. When the first drop falls from the end of the condenser, record the reading of the distillation thermometer as the *initial boiling point*. Move the receiving cylinder so that the end of the condenser tube shall touch the side of the cylinder. Then regulate the heat so that the distillation will proceed at a uniform rate of not less than 8 nor more than 10 ml per min. Separate a fraction at every temperature point above the initial boiling point that is a multiple of 50 F. In case the product is being tested to determine its conformity to specifications involving limits that are not multiples of 50 F, any readings may be taken, or fractions separated, which are called for by the specification requirements. If desired, 20-ml (10 per cent) fractions may be separated and readings made on the thermometer just as each graduate is withdrawn.

(*b*) When the temperature of the distilling vapors reaches 500 F (260 C), adjust the temperature of the water in the condenser bath to approximately 140 F (60 C) and the bath maintained between 140 and 160 F (60 to 71.1 C) for the remainder of the test. Continue the distillation until a vapor temperature of 700 F (371.1 C) is reached or until the maximum temperature point is reached. The maximum temperature point may result from complete distillation of the oil below 700 F (371.1 C), or from cracking (Note 2).

NOTE 2.—Cracking will be evidenced by an increase in distilling rate with a thermometer reading that may advance very slowly, remain stationary, or recede, and an effort to adjust the distilling rate will usually result in a decided drop in the temperature reading. When this condition is observed, it is advisable to discontinue the distillation.

(*c*) In case the oil distills completely below 700 F (371.1 C), make the final adjustment of heat when a quantity of distillate amounting to 90 per cent of the sample has been collected. Continue the heating until the thermometer reaches a maximum reading and starts to fall consistently; but in no case should the period between the 90 per cent point and the maximum temperature be more than 10 min. Record the highest temperature observed on the distillation thermometer as the *maximum temperature*. Allow sufficient time after distillation is completed for any distillate in the condenser to drain into the final fraction. Bring each fraction to room temperature, read and record the volume. Calculate and record the percentage of distillate in each fraction. Calculate and record the difference between 100 and the sum of the distillate percentages as *residue and loss.*

Reproducibility of Results

5. With proper care and strict attention to details, duplicate determinations by the same operator for end point should not differ from each other by more than 6 F (3.3 C) and differences in volumes of fractions separated at the various temperature limits should not exceed 4 ml. When temperatures are observed for specified percentages distilled the differences should not exceed 4 F (2.2 C). When duplicate determinations are made by different operators normal differences in observations are one and a half times those which are expected with a single operator.

Correction for Barometric Pressure

6. When it is agreed to make allowance for the effect of barometric pressure, correct the temperature points to 760 mm (29.92 in.), by the use of the Sidney Young equation as follows:

For Centigrade readings:

$$C_c = 0.00012\,(760 - P)(273 + t_c)$$

For Fahrenheit readings:

$$C_f = 0.00012\,(760 - P)(460 + t_f)$$

where:

C_c and C_f = the correction to be added to the observed temperature t_c or t_f, respectively, and

P = actual barometric pressure in millimeters of mercury.

Table I is a convenient approximation of the corrections as calculated by the above equations for those cases where the temperature for a specified volume is required.

TABLE I.

Temperature Range		Correction[a] per 10-mm Difference in Pressure	
deg Cent	deg Fahr	deg Cent	deg Fahr
10 to 30	50 to 86	0.35	0.63
30 to 50	86 to 122	0.38	0.68
50 to 70	122 to 158	0.40	0.72
70 to 90	158 to 194	0.42	0.76
90 to 110	194 to 230	0.45	0.81
110 to 130	230 to 266	0.47	0.85
130 to 150	266 to 302	0.50	0.89
150 to 170	302 to 338	0.52	0.94
170 to 190	338 to 374	0.54	0.98
190 to 210	374 to 410	0.57	1.02
210 to 230	410 to 446	0.59	1.06
230 to 250	446 to 482	0.62	1.11
250 to 270	482 to 518	0.64	1.15
270 to 290	518 to 554	0.66	1.19
290 to 310	554 to 590	0.69	1.24
310 to 330	590 to 626	0.71	1.28
330 to 350	626 to 662	0.74	1.32
350 to 370	662 to 698	0.76	1.37
370 to 390	698 to 734	0.78	1.41
390 to 410	734 to 770	0.81	1.45

[a] To be added in case barometric pressure is below 760 mm; to be subtracted in case barometric pressure is above 760 mm.

APPROVED AS
AMERICAN STANDARD
BY THE AMERICAN STANDARDS ASSOCIATION
ASA NO.: Z11.31-1955
UDC 665.5:620.1

Standard Method of Test for

API GRAVITY OF PETROLEUM AND ITS PRODUCTS[1]

HYDROMETER METHOD

ASTM Designation: D 287 - 55

ADOPTED, 1954; REVISED, 1955.[2]

This Standard of the American Society for Testing Materials is issued under the fixed designation D 287; the final number indicates the year of original adoption as standard or, in the case of revision, the year of last revision.

Scope

1. This method describes a procedure for the determination by means of a glass hydrometer of the API gravity (in vacuum) of crude petroleum and of petroleum products normally handled as liquids and having a Reid vapor pressure of 26 lb or less. Results are determined at 60 F, or converted to values at 60 F, by means of standard Tables.

NOTE 1.—The procedure for measurement of specific gravity 60/60 F by hydrometer is described in ASTM Method D 1298[3]. For measurement of specific gravity 77/77 for road oils, road tars, asphalt cements and soft tar pitches see ASTM Method D 70[4]; for measurement of specific gravity 77/77 F of hard penetration asphalt see ASTM Method D 71[4]; for measurement of specific gravity 15.56/15.56 C of industrial aromatics see ASTM Method D 891[5]; for measurement of density of hydrocarbon liquids see ASTM Method D 941[3]; for measurement of density and specific gravity of liquids by Bingham Pycnometer, see ASTM Method D 1217.[3]

Definition

2. *API Gravity* is defined by the following equation:

$$\text{API Gravity, deg} = \frac{141.5}{\text{sp gr } 60/60 \text{ F}} - 131.5$$

Apparatus

3. The following apparatus is required:

(*a*) *Hydrometers*, of glass, graduated in degrees API (in vacuum) as listed in Table I and conforming to the Tentative Specifications for ASTM Hydrometers (ASTM Designation: E 100).[3] For referee testing of petroleum products, the long plain form of hydrometer (1H to 10H) should be used.

TABLE I.—AVAILABLE API HYDROMETERS.

ASTM Designation	Type	API Range	
		Total	Each Hydrometer
1H to 10H	long plain form	−1 to 101	12
21H to 40H	short plain form	0 to 101	6
51H to 60H	thermo-hydrometer	−1 to 101	12
71H to 74H	thermo-hydrometer	−1 to 41	12

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[1] Under the standardization procedure of the Society, this method is under the jurisdiction of the ASTM Committee D-2 on Petroleum Products and Lubricants.

[2] Prior to adoption as standard, this method was published as tentative from 1952 to 1954.

This method together with the Standard Method of Test for Specific Gravity of Petroleum and Its Products (Hydrometer Method) (D 1298 - 54) replace the former Standard Method of Test for Gravity of Petroleum and Its Products by Hydrometer (D 287 - 52).

In 1955, in Section 5(*d*) "half scale" was changed to "scale." In Section 7, repeatability was changed to "0.2" from "0.1."

[3] Appears in this publication, see Contents in Numeric Sequence of ASTM Designations at front of book.

[4] 1958 Book of ASTM Standards, Part 4.

[5] 1958 Book of ASTM Standards, Part 8.

(*b*) *Thermometers*, having a range of −5 to +215 F and conforming to the requirements for Thermometer 12F as prescribed in ASTM Specifications E 1.[3]

(*c*) *Hydrometer Cylinders*, made of metal, clear glass, or plastic. For convenience in pouring, the cylinder may have a lip on the rim. The inside diameter of the cylinder shall be at least 25 mm greater than the outside diameter of the hydrometer used in it. The height of the cylinder shall be such that the length of the column of sample it contains is greater by at least 25 mm than the portion of the hydrometer which is immersed beneath the surface of the sample.

TABLE II.—LIMITING CONDITIONS AND TEST TEMPERATURES.

Sample Type	Gravity Limits	Initial Boiling Point Limits	Other Limits	Test Temperature
Highly volatile	Lighter than 70° API	...	...	Cool to 35 F or lower in original closed container
Moderately volatile	Heavier than 70° API	Below 250 F	...	Cool to 65 F or lower in original closed container
Moderately volatile and viscous	Heavier than 70° API	Below 250 F	Viscosity too high at 65 F	Heat to minimum temperature for sufficient fluidity
Nonvolatile	Heavier than 70° API	Above 250 F	...	Any temperature between 0 and 195 F as convenient
Mixtures of non-petroleum with petroleum products	...	...	...	60 ± 0.25 F

Temperature of Test

4. The gravity determined by the hydrometer method is most accurate at or near the standard temperature of 60 F; use this or any other temperature between 0 and 195 F for test so far as it is consistent with the type of sample and necessary limiting conditions shown in Table II.

Procedure

5. (*a*) Adjust the temperature of the sample in accordance with Table II. The hydrometer cylinder and thermometer shall be at approximately the same temperature as the sample to be tested.

(*b*) Pour the sample into the clean hydrometer jar without splashing, so as to avoid the formation of air bubbles and to reduce to a minimum the evaporation of the lower-boiling constitutents of the more volatile samples. For the more volatile samples, transfer to the hydrometer cylinder by siphoning. Remove any air bubbles formed, after they have collected on the surface of the sample, by touching them with a piece of clean filter paper before inserting the hydrometer. Place the cylinder containing the sample in a vertical position in a location free from air currents. Take precautions to prevent the temperature of the sample from changing appreciably during the time necessary to complete the test. During this period, the temperature of the surrounding medium should not change by more than 5 F.

(*c*) Lower the hydrometer gently into the sample and, when it has settled. depress it about two scale divisions into the liquid and then release; keep the rest of the stem dry, as unnecessary liquid on the stem changes the effective weight of the instrument, and so affects the reading obtained. With samples of low viscosity, a slight spin imparted to the instrument on releasing assists in bringing it to rest, floating freely away from the walls of the hydrometer cylinder. Allow sufficient time for the hydrometer to become completely stationary and for all air bubbles to come to the surface. This is particularly necessary in the case of the more viscous samples.

(*d*) When the hydrometer has come to rest, floating freely, and the temperature of the sample is constant to 0.2 F, read the hydrometer to the nearest scale division. The correct reading is that point on the hydrometer scale at which the surface of the liquid cuts the scale. Determine this point by placing the eye slightly below the level of the liquid and slowly raising it until the surface, first seen as a distorted ellipse, appears to become a straight line cutting the hydrometer scale.

(*e*) To make a reading with nontransparent oils, observe the point on the hydrometer scale to which the sample rises above its main surface, placing the eye slightly above the plane surface of the liquid. This reading requires a correction. Determine this correction for the particular hydrometer in use by observing the height above the main surface of the liquid to which the oil rises on the hydrometer scale when the hydrometer in question is immersed in a transparent oil having a surface tension similar to that of the sample under test.

(*f*) Observe the temperature of the sample to the nearest 0.25 F immediately before and after the observation of the gravity, the liquid in the cylinder being thoroughly but cautiously stirred with the thermometer, the whole of the mercury thread being immersed. Should these temperature readings differ by more than 1 F, repeat the temperature and gravity observations when the temperature of the sample has become more stable. Record the mean of the thermometer reading before and after the final hydrometer reading, to the nearest degree Fahrenheit, as the temperature of the test.

NOTE 2.—When thermo-hydrometers are used, stir the sample by carefully raising and lowering the hydrometer. It is satisfactory in this case to read the thermometer scale after the hydrometer reading has been observed. Because the thermometer incorporated in the hydrometer possesses certain inherent defects of design, the precision of the reported value will be poorer than that described in Section 7.

Calculation

6. (*a*) When gravities have been observed on opaque liquids by the procedure given in Section 5(*e*), subtract the correction in degrees API from the hydrometer reading observed.

(*b*) Correct all hydrometer readings to 60 F, using Table 5, "Reduction of Observed API Gravity to API Gravity at 60°F," of the ASTM-IP Petroleum Measurement Tables (American Edition).[6]

NOTE 3.—The interconversion of API gravity to specific gravity is given in Table 3, "API Gravity at 60° F to Specific Gravity at 60° F and to Density at 15° C" of the ASTM-IP Petroleum Measurement Tables (American Edition).[6]

(*c*) Equivalent results can be obtained by determining specific gravity 60/60 F according to Method D 1298 and converting the results to API Gravity at 60 F by means of Table 3 of the ASTM-IP Petroleum Measurement Tables (American Edition).[6]

Precision

7. The following criteria should be used for judging the acceptability of results obtained at temperatures differing from 60 F by less than 18 F:

	Repeatability Duplicate Results by the Same Operator	**Reproducibility** Average of Two Results in Each of Two Laboratories
Degree API.......	0.2	0.5

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[6] Published jointly by, and available from, the American Society for Testing Materials, 1916 Race St., Philadelphia 3, and the Institute of Petroleum, 26 Portland Place, London W-1. Companion volumes—the British Edition and the Metric Edition—are also available. These tables supersede all other similar tables previously published by either of these Societies, and the National Bureau of Standards *Circular C-410* and the *Supplement to Circular C-410*.

APPROVED AS
AMERICAN STANDARD
BY THE AMERICAN STANDARDS ASSOCIATION
ASA NO.: Z11.2-1956
UDC 665.5:532.13:620.1
AMERICAN ASSOCIATION STATE
HIGHWAY OFFICIALS STANDARD
A.A.S.H.O. NO.: T 72

Standard Method of Test for
SAYBOLT VISCOSITY[1]

ASTM Designation: D 88 - 56

Adopted, 1926; Revised, 1930, 1933, 1936, 1938, 1944, 1953, 1955, 1956.[2]

This Standard of the American Society for Testing Materials is issued under the fixed designation D 88; the final number indicates the year of original adoption as standard or, in the case of revision, the year of last revision.

Note.—Footnote 2*a* was added editorially in August, 1957. Figure 5 was editorially revised in September, 1958. Appendix II was revised editorially in November, 1958.

Scope

1. This method describes procedures for the empirical measurement of Saybolt viscosity of petroleum products[2a] at specified temperatures between 70 and 210 F. There is also included a special procedure for waxy and resinous materials.

Note 1.—A fundamental and preferred method for measuring viscosity is by use of kinematic viscometers as outlined in ASTM Method D 445, Test for Kinematic Viscosity.[3] This method requires smaller samples, less time, and gives greater accuracy.

Saybolt Universal and Saybolt Furol viscosities may be obtained from kinematic viscosity values by the use of conversion tables given in ASTM Method D 446, Conversion of Kinematic Viscosity to Saybolt Universal Viscosity,[3] and ASTM Method D 666, Conversion of Kinematic Viscosity to Saybolt Furol Viscosity,[3] respectively.

Viscosity index calculation from kinematic viscosity is recommended over viscosity index calculations using Saybolt Universal values.

Saybolt Furol Viscosity of Asphaltic Materials at High Temperatures is covered by ASTM Method E 102.[3]

Definition

2. (*a*) *Saybolt Universal Viscosity.*—The efflux time in seconds of 60 ml of sample flowing through a calibrated Universal orifice under specified conditions.

(*b*) *Saybolt Furol Viscosity.*—The efflux time in seconds of 60 ml of sample flowing through a calibrated Furol orifice under specified conditions. The Furol viscosity is approximately one-tenth the Universal viscosity, and is recommended for those petroleum products having viscosities greater than 1000 sec (Saybolt Universal), such as fuel oils, and other residual materials. The word "Furol" is a contraction of fuel and road oils.

Outline of Method

3. The efflux time in seconds of 60 ml of sample, flowing through a calibrated

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[1] Under the standardization procedure of the Society, this method is under the jurisdiction of the ASTM Committee D-2 on Petroleum Products and Lubricants.

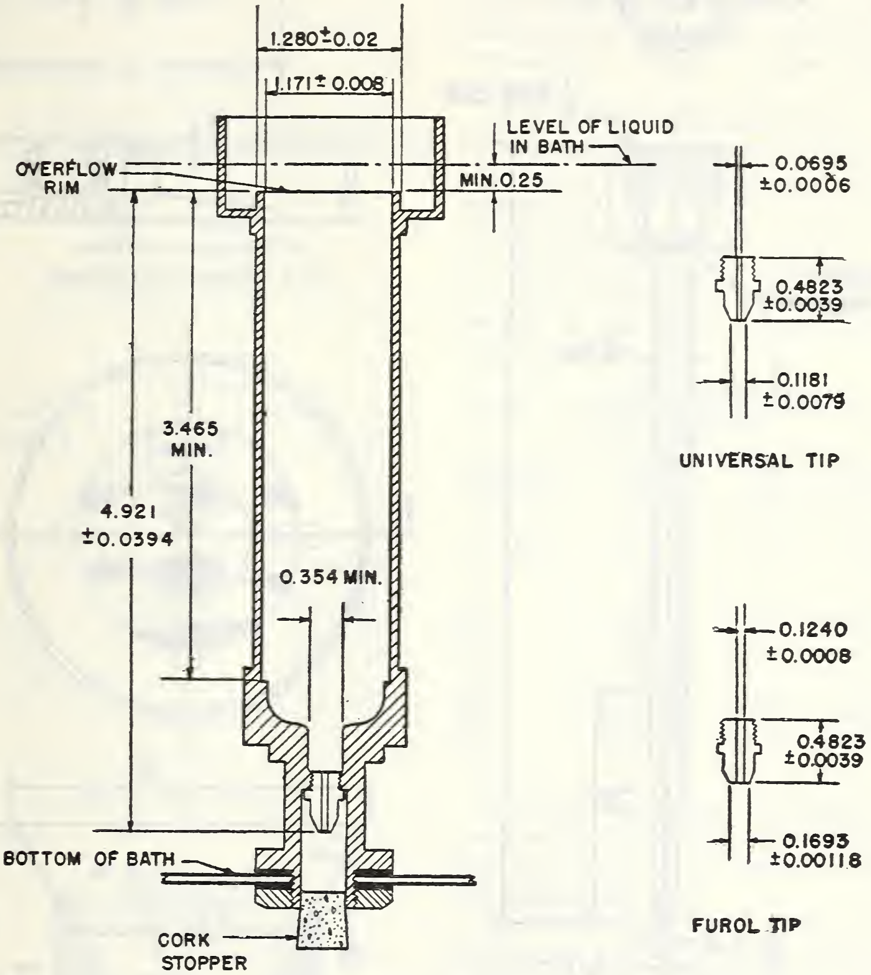
[2] Prior to adoption as standard, this method was published as tentative from 1921 to 1926, being revised in 1923 when it was combined with the Methods of Test for Viscosity by Means of the Saybolt Standard Universal Viscosimeter (D 47 - 21), and again revised in 1924, 1925, and 1926.

In 1956, a new Section 8 was added in order to make the method applicable to waxy or resinous materials. Other editorial revisions were made.

[2a] Statements defining this test and its significance when applied to electrical insulating oils of mineral origin will be found in ASTM Methods D 117, Testing Electrical Insulating Oils, see p. 55.

[3] 1958 Book of ASTM Standards, Part 7.

orifice, is measured under carefully controlled conditions. This time is corrected by an orifice factor, and reported as the viscosity of the sample at that temperature.



All Dimensions in Inches

Fig. 1.—Saybolt Viscometer with Universal and Furol Orifice.

Apparatus

4. (*a*) *Saybolt Viscometer and Bath*, as described in Appendix I.

(*b*) *Withdrawal Tube* as shown in Fig. 2.

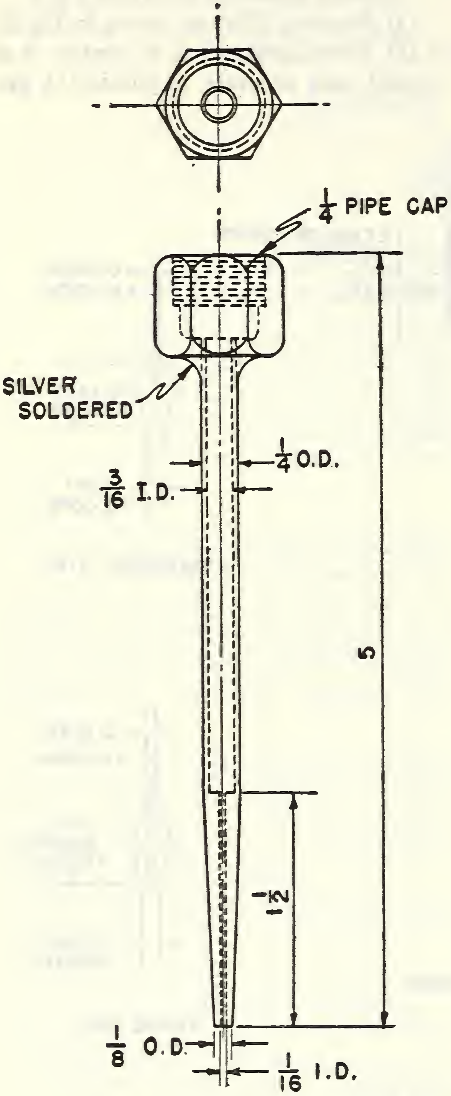
(*c*) *Thermometer Support* as shown in Fig. 3.

(*d*) *Filter Funnel* as shown in Fig. 4.

(*e*) *Receiving Flask* as shown in Fig. 5.

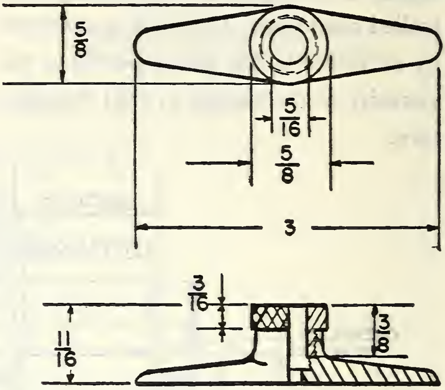
(*f*) *Timer*, graduated in tenths of a second, and accurate to within 0.1 per cent when tested over a 60-min interval. Electric timers are acceptable if operated on a controlled frequency circuit.

(*g*) *Viscosity Thermometers*, for reading the test temperature of the sample. The ASTM Saybolt Viscosity Thermometers



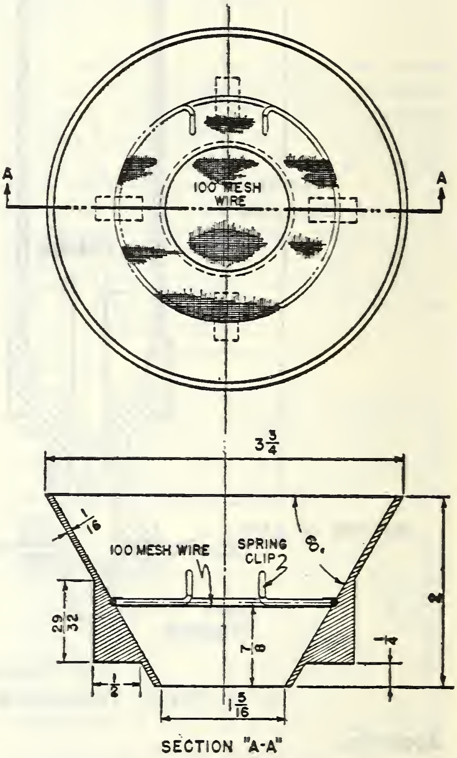
All Dimensions in Inches

FIG. 2.—Withdrawal Tube for Use with Saybolt Viscometer.



All Dimensions in Inches

FIG. 3.—Thermometer Support.



All Dimensions in Inches

FIG. 4.—Filter Funnel for Use with Saybolt Viscometer.

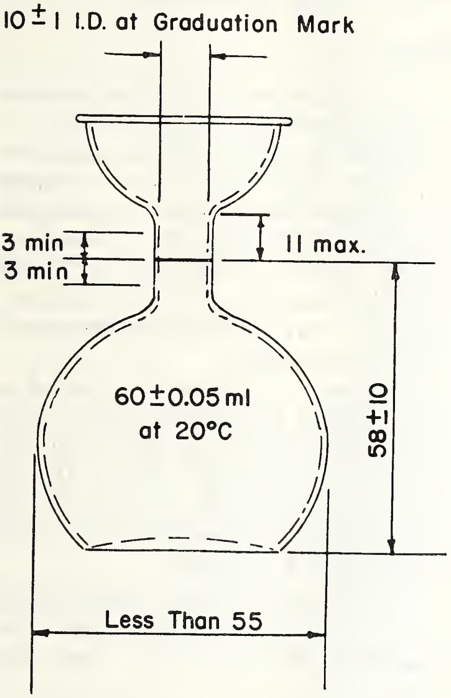
P-40-1

shown in Table I shall conform to the requirements in ASTM Specifications E 1.[4]

(*h*) *Bath Thermometers.*—Viscosity thermometers, or any other means of equivalent accuracy.

Preparation of Apparatus

5. (*a*) Use a Universal orifice for lubricants and distillate materials with efflux times greater than 32 sec to give the desired accuracy. Liquids with efflux times over 1000 sec are not conveniently tested with this orifice.



All Dimensions in Millimeters
FIG. 5.—Receiving Flask.

(*b*) Use a Furol orifice for residual materials with efflux times greater than 25 sec. The Furol efflux time is approximately one-tenth the Universal efflux time.

NOTE 2.—The Universal orifice is used at 70, 100, 130, and 210 F. The Furol orifice is used at 77, 100, 122, and 210 F.

(*c*) Set up the viscometer and bath where they will be free from drafts and rapid changes in air temperature. Locate them so that the sample will not be contaminated by dust or vapors during the test.

(*d*) Viscosity determinations shall not be made at temperatures below the dew point of the room's atmosphere. Room temperatures up to 100 F will not introduce errors in excess of 1.0 per cent. For standardization and referee tests, the room temperature shall be kept between 68 and 86 F, and the actual temperature recorded.

TABLE I.—ASTM SAYBOLT VISCOSITY THERMOMETERS.

Standard Test Temperature, deg Fahr	Temperature Range, deg Fahr	Subdivisions, deg Fahr	ASTM Thermometer No.
70	66 to 80	0.2	17 F
77	66 to 80	0.2	17 F
100	94 to 108	0.2	18 F
122	120 to 134	0.2	19 F
130	120 to 134	0.2	19 F
140	134 to 148	0.2	20 F
180	174 to 188	0.2	21 F
210	204 to 218	0.2	22 F

(*e*) Fill the bath at least ¼ in. above the overflow rim of the viscometer. Table II lists recommended bath media for each test temperature.

(*f*) Provide adequate stirring and thermal control for the bath so that the sample will not fluctuate more than ±0.05 F after reaching the test temperature.

(*g*) Clean the viscometers with an effective nontoxic solvent and remove all solvent from the gallery and viscometer.

NOTE 3.—The plunger commonly supplied with the viscometer should never be used for cleaning as the overflow rim and walls of the viscometer may be damaged by its use.

Calibration of Viscometers

6. (*a*) Calibrate the Saybolt Universal viscometer at periodic intervals by measuring the efflux time at 100 F of an appropriate viscosity standard, following the procedure given in Section 7. See Appendix II.

TABLE II.—BATH TEST TEMPERATURES.

Standard Test Temperature, deg Fahr	Recommended Bath Medium	Maximum Temperature Differential,[a] deg Fahr	Functional Precision
70	Water.................	±0.1	±0.05
77	Water.................	±0.1	±0.05
100	Water, or Oil of viscosity 50 to 70 sec S.U. at 100 F	+0.25	±0.05
122	Water, or Oil of viscosity 120 to 150 sec S.U. at 100 F..............	+0.35	±0.05
130	Water, or Oil of viscosity 120 to 150 sec S.U. at 100 F..............	+0.5	±0.05
140	Water, or Oil of viscosity 120 to 150 sec S.U. at 100 F	+1.0	±0.1
180	Water, or Oil of viscosity 330 to 370 sec S.U. at 100 F..............	+1.5	±0.1
210	Oil of viscosity 330 to 370 sec S.U. at 100 F..	+2.0	±0.1

S.U. = Saybolt Universal.

[a] Maximum difference allowed between bath temperature and test temperature to maintain thermal equilibrium while stirring sample in viscometer with test thermometer.

(*b*) The efflux time shall equal the certified Saybolt viscosity value. If the efflux time differs from the certified value by more than 0.2 per cent, calculate a correction factor, *F*, for the viscometer as follows:

$$F = \frac{V}{t}$$

where:

V = certified Saybolt viscosity of the standard, and

t = efflux time in seconds at 100 F.

NOTE 4.—The correction factor applies at all viscosity levels and for all temperatures, provided the calibration is based on a viscosity standard having an efflux time between 200 and 600 sec.

(*c*) Calibrate the Saybolt Furol viscometer at 122 F in the same manner as above, using a viscosity standard having a minimum efflux time of 90 sec.

(*d*) Viscometers or orifices which have corrections in excess of 1.0 per cent shall not be used for referee testing.

Procedure

7. (*a*) If the test temperature is above room temperature, the test may be expedited by preheating the sample to not more than 3 F above the test temperature. Never preheat any sample to within 50 F of its flash point (see ASTM Method D 93, Test for Flash Point by Means of the Pensky-Martens Closed Tester),[3] as volatility losses may alter its composition.

(*b*) Insert a cork stopper, having a cord attached for its easy removal, into the air chamber at the bottom of the viscometer. The cork shall fit tightly enough to prevent the escape of air, as evidenced by the absence of oil on the cork when it is withdrawn.

(*c*) Filter the prepared sample through a 100-mesh screen directly into the viscometer until the level is above the overflow rim.

(*d*) Stir the sample until its temperature remains constant within 0.05 F of the test temperature during 1 min of continuous stirring. Stir with a viscosity thermometer equipped with a thermometer support (Fig. 3). Use a circular motion at 30 to 50 rpm in a horizontal plane.

NOTE 5.—Never adjust the temperature by immersing hot or cold bodies into the sample. Such thermal treatment may affect the sample and the precision of the test.

(*e*) Remove the thermometer from the sample. Quickly remove the oil from the gallery until its level is below the overflow rim. This is done by placing the tip of the withdrawal tube (Fig. 2) at one point in the gallery and applying suction. Do not touch the overflow rim with the withdrawal tube, or the effective head of the sample will be reduced.

(*f*) Place the receiving flask (Fig. 5) where the stream of oil from the bottom of the viscometer will just strike the neck of the flask. The graduation mark on the flask shall be between 10 and 13 cm from the bottom of the viscometer tube.

(*g*) Snap the cork from the viscometer using the attached cord. At the same instant start the timer. Stop the timer the instant the bottom of the meniscus reaches the graduation mark. Record the efflux time in seconds.

Special Procedure for Waxy or Resinous Materials

8. (*a*) Steam-refined cylinder oils, black lubricating oils, residual fuel oils, and other materials which may possibly contain waxes or resins require special handling to obtain reproducible results. In order to control the possible anomalies in testing such material, the thermal history of the sample shall be controlled. This special procedure will aid in the control of wax crystals and lattice structure formations.

(*b*) Heat the filtered sample in a loosely stoppered container for 1 hr in an oven maintained at 212 to 215 F.

(*c*) Immediately pour the sample into the clean, stoppered viscometer without refiltering. Place a thermometer with support into the sample. Do not disturb the sample until it is 1 F above test temperature.

(*d*) When the sample reaches this temperature, stir it with the thermometer using a circular motion, at 30 to 50 rpm, until the temperature of the sample remains constant within 0.05 F of the test temperature during 1 min of continuous stirring.

(*e*) Complete the test as described in Section 7 (*e*), (*f*), and (*g*).

(*f*) Viscosity determinations of these materials shall be completed within 1 hr after filling the viscometer with sample. Do not run repeat determinations on the same portion of these materials.

Calculation and Report

9. (*a*) Multiply the efflux time by the calibration factor for the viscometer used.

(*b*) Report the corrected time in seconds as the Saybolt Universal viscosity or Saybolt Furol viscosity of the oil at the temperature at which the test was made.

(*c*) Report the values below 200 sec to the nearest 0.1 sec. Report all values of 200 sec or higher to the nearest whole second.

EDITORIAL NOTE

The following section on precision is under review and study by Section A of Research Division VII of Committee D-2 on Petroleum Products and Lubricants, and is published here as information only.

10. *Precision.*—Results in different laboratories with different operators under referee or standardization conditions of testing should not differ by more than 0.5 per cent.

P 41-50

APPENDIX I

SAYBOLT VISCOMETER AND ACCESSORIES

Viscometer

A1. The viscometer, illustrated in Fig. 1, shall be constructed entirely of corrosion-resistant metal, conforming to dimensional requirements shown in Fig. 1. The orifice tip, Universal or Furol, may be constructed as a replaceable unit in the viscometer. Provide a nut at the lower end of the viscometer for fastening it in the bath. Mount vertically in the bath and test the alignment with a spirit level on the plane of the gallery rim. Provide a cork or other suitable means to prevent the flow of sample until the start of the test; a small chain or cord may be attached to the cork to facilitate rapid removal.

Bath

A2. The bath serves both as a support to hold the viscometer in a vertical position as well as the container for the bath medium. Equip the bath with effective insulation and with an efficient stirring device. Provide the bath with a coil for heating and cooling and with thermostatically controlled heaters capable of maintaining the bath within the functional precision given in Table II. The heaters and coil should be located at least 3 in. from the viscometer. Provide a means for maintaining the bath medium at least $\frac{1}{4}$ in. above the overflow rim. The bath media are given in Table II.

APPENDIX II

VISCOSITY STANDARDS

A3. Viscosity standards are available from two sources. These standards may be used with equal confidence provided they are used immediately after opening and not stored for re-use as permanent viscosity standards.

Standards Conforming to ASTM Saybolt Viscosity Standards

A4. Viscosity Oil Standards conforming to the requirements of ASTM Viscosity Oil Standards for viscometer calibration having certified Saybolt viscosity values established by cooperative determinations of kinematic viscosity values. The kinematic values are converted to Saybolt Universal and Saybolt Furol viscosity values by means of conversion tables given in ASTM Methods D 446 and D 666, respectively. The Viscosity Oil Standards are oils with approximate Saybolt viscosities as shown in Table III.

NBS Viscosity Standards

A5. National Bureau of Standards liquid viscosity standards having accurate values supplied with each sample. Standard SB has a Saybolt Universal viscosity of approximately 300 sec at 100 F. Standard SF has a Saybolt Furol viscosity of approximately 100 sec at 122 F.

NOTE 7.—The NBS viscosity standards are available only as 1-pt samples at $6.50 per sample FOB Washington, D. C. Purchase orders should be addressed to the National Bureau of Standards, Washington 25, D. C.

Routine Calibrations

A6. The viscosity standards may also be used

TABLE III.—SAYBOLT VISCOSITY STANDARDS.[a]

Viscosity Oil Standards Conforming to ASTM Standards	Approximate Saybolt Viscosity, sec		
	Universal		Furol At 122 F
	At 100 F	At 210 F	
S 3........	36	...	...
S 6........	46	...	...
S 20.......	100	...	...
S 60.......	290	...	...
S 200......	970	...	...
S 600......	...	150	133

[a] These are approximate values only. Certified values are supplied with each shipment. These viscosity oil standards are available as 1-pt samples at $15.00 per sample, F.O.B. State College, Pa. Purchase orders should be addressed to the Cannon Instrument Co., P.O. Box 812, State College, Pa. Shipment will be made as specified or by best means.

for routine calibrations at other temperatures as shown in Table III.

Other Viscosity Standards

A7. Other reference liquids, suitable for routine calibrations, may be established by selecting stable oils covering the desired range and determining their viscosities in a viscometer calibrated with a standard conforming to ASTM requirements or an NBS standard as described in Section 6.

AMERICAN ASSOCIATION STATE
HIGHWAY OFFICIALS STANDARD
A.A.S.H.O. NO.: T 67

Tentative Methods of
VERIFICATION OF TESTING MACHINES[1]

ASTM Designation: E 4 – 57 T

ISSUED, 1947; REVISED, 1950, 1955, 1957.[2]

These Tentative Methods have been approved by the sponsoring committee and accepted by the Society in accordance with established procedures for use pending adoption as standard. Suggestions for revisions should be addressed to the Society at 1916 Race St., Philadelphia 3, Pa.

NOTE.—Editorial changes were made in Sections 8, 10, 11(*a*), 14, 15(*a*), and 15(*b*) in August, 1958.

Scope

1. These methods cover four procedures for the verification by means of standard calibrating devices of testing machines that are designed to measure loads, as follows:

A. Verification by standard weights,
B. Verification by standardized proving levers,
C. Verification by equal-arm balances and standard weights, and
D. Verification by elastic calibration devices.

NOTE.—These methods are not intended to be complete purchase specifications for testing machines. Purchase specifications usually state the maximum permissible errors from zero to capacity load for each scale range of the machine.

Definitions

2. (*a*) *Testing Machine.*—A mechanical device for applying a load (force) to a specimen.

NOTE.—Usually the magnitude of the load can be changed at the will of the operator. Many testing machines are arranged to measure the load, but this is not always the case, especially with impact machines and machines for testing ductility.

(*b*) *Accurate.*—A testing machine is said to be accurate if the indicated load is within the specified permissible variation from the actual load.

NOTE.—In these methods the word "accurate" applied to a testing machine is used without numerical values, for example, "An accurate testing machine was used for the investigation."

The *accuracy* of a testing machine should not be confused with *sensitivity*. For example, a testing machine might be very sensitive; that is, it might indicate quickly and definitely small changes in load, but, nevertheless, be very inaccurate. On the other hand, the accuracy of the results is in general limited by the sensitivity.

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[1] Under the standardization procedure of the Society, these methods are under the jurisdiction of the ASTM Committee E-1 on Methods of Testing.

[2] Latest revision accepted by the Society at the Annual Meeting, June, 1957.

These methods, together with the Tentative Methods of Verification of Calibration Devices for Verifying Testing Machines (E 74), represent a revision of and replace the former Standard Methods E 4 – 36.

Prior to their present publication as tentative, these methods were published as tentative from 1923 to 1924, being revised in 1924. They were adopted in 1924, but withdrawn and republished as tentative from 1933 to 1936, being revised in 1934, 1935, and 1936. They were again adopted in 1936 and published as standard from 1936 to 1947.

(*c*) *Error.*—In the case of a testing machine, the value obtained by subtracting the value indicated by the calibrating device from the value indicated by the testing machine.

NOTE.—The word "error" shall be used with numerical values, for example, "At a load of 30,000 lb, the error of the testing machine was +15 lb."

(*d*) *Percentage of Error.*—In the case of a testing machine, the ratio, expressed as a percentage, of the error to the correct value of the quantity measured.

(*e*) *Correction.*—In the case of a testing machine, the value obtained by subtracting the indicated value from the correct value of the quantity measured.

NOTE.—The correction has the same magnitude as the error, but the opposite sign. It is recommended that, except for special cases, no corrections be used on machines tested and found to have errors within the permissible variations given in these methods.

(*f*) *Permissible Variation* (*or Tolerance*).—In the case of testing machines, the maximum allowable error in the value of the quantity indicated.

NOTE.—It is convenient to express permissible variation in terms of percentage of error. The numerical value of the permissible variation for a testing machine is so stated hereafter in these methods.

(*g*) *Capacity Range.*—The nominal capacity range of a testing machine is the range of loads for which it is designed. Some testing machines have more than one capacity range.

(*h*) *Loading Range.*—The loading range of a testing machine is the range of indicated loads for which the testing machine gives results within the permissible variations specified.

Calibration Devices

3. Testing machines shall be verified, using calibration devices which comply with the requirements of the Methods of Verification of Calibration Devices for Verifying Testing Machines (ASTM Designation: E 74).[3]

Advantages and Limitations of Methods

4. (*a*) *Verification by Standard Weights.*—Verification by the direct application of standard weights to the weighing mechanism of the testing machine, where practicable, is the most accurate method. Its limitations are (*1*) the small range of load which can be covered, (*2*) the nonportability of any large amount of standard weights, and (*3*) its nonapplicability to horizontal testing machines or to vertical testing machines the weighing mechanisms of which are not designed to be actuated by a downward force.

(*b*) *Verification by Proving Levers.*—The second method of verification involves the use of a pair of standardized proving levers. The limitations of this second method are the same as for the verification by standard weights. The range of load practicable with proving levers is much greater than that practicable with standard weights, but the range of load for proving levers is not great enough to cover the capacity load of many large testing machines.

(*c*) *Verification by Equal-Arm Balance and Standard Weights.*—The third method of verification of testing machines involves measurement of the load by means of an equal-arm balance and standard weights. This method is limited to a still smaller range of loads than either of the foregoing methods, and is generally applicable only to certain types of hardness testing machines in which the load is applied through an internal lever system.

(*d*) *Verification by Elastic Calibration Devices.*—The fourth method of verification of testing machines involves measurement of the elastic strain or deflection under load of a ring, loop, tension or compression bar, or other elastic device. The elastic calibration device is free from the limitations referred to in Paragraphs (*a*) and (*b*).

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[3] See p. 424.

Method of Applying Load

5. In the verification of a testing machine, the loads shall be approached by increasing the load from a lower load.

NOTE.—For any testing machine the errors observed at corresponding loads taken first by increasing the load to any given test load and then by decreasing the load to that test load, may not agree. This disagreement is especially likely in types of machines in which the load-indicating device is actuated by a Bourdon pressure tube, by a hydraulic indicator or a steam-engine indicator, or by any other load-indicating device depending on the elastic properties of a material. It is also likely to occur in a testing machine in which the load is measured by measuring the pressure in a hydraulic jack.

Testing machines are usually used under increasing loads, but if a testing machine is to be used under decreasing loads, it should be calibrated under decreasing loads as well as under increasing loads.

Selection of Test Loads

6. For any loading range, the testing machine shall be verified by at least five test loads (except for testing machines designed to measure only a smaller number of definite loads, such as certain hardness testing machines). The difference between any two successive test loads shall not exceed one third of the difference between the maximum and minimum test loads. If it is desired to establish the lower limit of a loading range lower than 10 per cent of the capacity of the range, the lower limit shall be verified by applying five approximately equal test loads, none of which shall differ from the lowest by more than 5 per cent.

Eccentric Loading

7. For the purpose of determining the loading range of a testing machine, all calibration loads shall be applied so that the resultant load shall be as nearly along the axis of a testing machine as is possible.

NOTE.—The effect of eccentric load on the accuracy of a testing machine may be determined by calibration readings taken with proving levers or an elastic calibration device placed so that the resultant load is applied at definite distances from the axis of the machine, and the loading range determined for a series of eccentricities. In the case of testing machines in which the load reading depends on the hydrostatic pressure in a cylinder fitted with a piston, the effect of eccentricity of loading is most serious when the piston is at the most extreme outward position.

A. VERIFICATION BY STANDARD WEIGHTS

Procedure

8. Standard metal weights of suitable design, finish, and adjustment shall be placed on the weighing platform of the testing machine or on trays or other supports suspended from the load measuring mechanism in place of the specimen. Weights certified within less than five years to be correct within a limit of error of 0.1 per cent shall be used. The weights shall be applied in increments and removed in the reverse order. They shall be arranged symmetrically with respect to the weighing platform, so that the center of gravity of the load lies in the vertical line through the center of the platform. The applied load and the indicated load shall be recorded for each test load applied, and the error and the percentage of error calculated from these data.

NOTE 1.—The method of verification by direct application of standard weights can be used only on vertical testing machines in which the pressure on the weighing table, hydraulic support, or other weighing device is downward. The total load is limited by the size of the platform and the number of weights available. 50-lb weights are usually convenient to use. This method of verification is confined to small testing machines and is rarely used above one or two thousand pounds.

NOTE 2.—In connection with the required limit of error of 0.1 per cent it may be noted that, in addition to the National Bureau of Standards, many of the states, some counties, and some universities have departments or offices of weights and measures equipped and staffed to certify weights up to 50 lb within the class "C" tolerances of the Bureau of Standards. These are closer tolerances than the requirement of a limit of error of 0.1 per cent.

B. VERIFICATION BY STANDARDIZED PROVING LEVERS

Levers

9. The common arrangement of proving levers for verification of testing machines is shown in Fig. 1. The two levers rest on supports on the weighing platform of the testing machine. These supports shall move easily in a horizontal direction, which insures that the forces at each of the knife edges, or other bearings, shall be very nearly vertical. The inner knife edges in each lever shall bear against a suitable block in the crosshead of the testing machine. Weight trays or hangers shall be suspended from each of the outer knife edges, and these trays or hangers shall be loaded with standard weights. Weights certified within less than five years to meet a tolerance of 0.02 per cent accuracy shall be used. The increment of load put on the testing machine by the standard weights is the amount of standard weights multiplied by the lever ratio m/n, Fig. 1.

NOTE.—In testing machines having a hydraulic support, or other load-weighing mechanism in the crosshead with the load during a test pressing upward against the crosshead instead of downward to the table, the lever ratio is $(m - n)/n$.

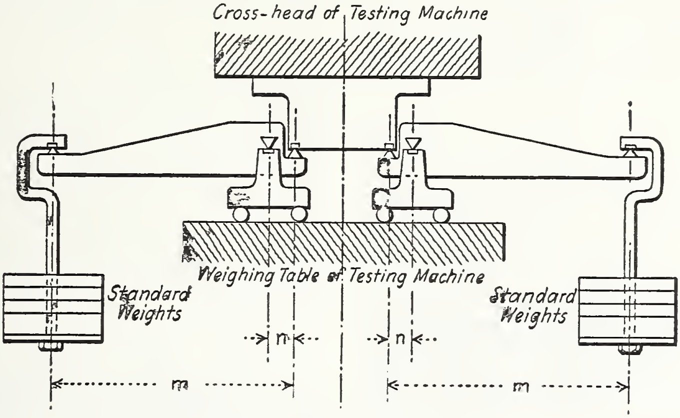
Cross-head of Testing Machine
Weighing Table of Testing Machine
Standard Weights
Standard Weights
n
n
m
m

FIG. 1.—Proving Levers.

Procedure

10. The proving levers shall be placed in the testing machine to be verified so that the resultant load line shall be coincident with the vertical line through the center of the weighing platform. Both levers shall be brought as near to a horizontal position as is feasible, after applying each increment of load, by means of the movable head of the testing machine. The testing machine shall be balanced with the levers in place and the weight trays empty. Standard weights shall be applied (or removed) in increments, half an increment in (or from) each tray. The weights shall be placed symmetrically on the weight trays with the center of gravity of the weights as nearly over the center of the tray as is feasible. The applied load and the indicated load shall be recorded for each test load applied, and the error and the percentage of error calculated from these data.

NOTE.—The use of standardized proving levers on horizontal testing machines involves the use of bell crank levers. Such levers require special methods of determination of lever ratio, which have not yet been codified in ASTM standards. Proving levers for vertical testing machines are now available up to 50,000-lb capacity.

C. VERIFICATION BY EQUAL-ARM BALANCE AND STANDARD WEIGHTS

11. (*a*) The balance shall be positioned so that the indenter of the testing machine being calibrated bears against a block centered on one pan of the equal arm balance, the balance being in its equilibrium position when the indenter is in that portion of its travel normally occupied when making an impression. Standard weights complying with the requirements in Section 8 of these methods shall be placed on the opposite pan to balance the load exerted by the indenter.

NOTE.—This method may be used for the verification of testing machines other than hardness testing machines by positioning the load-applying member of the testing machine in the same way that the indenter of a hardness testing machine is positioned.

(*b*) Since the permissible travel of the indenter of a hardness testing machine is usually very small, the balance shall not be allowed to oscillate or swing. Instead, the balance shall be maintained in its equilibrium position through the use of an indicator such as an electric contact, which shall be arranged to indicate when the reaction of the indenter load is sufficient to lift the pan containing the standard weights.

(*c*) Using combinations of fractional weights, both the maximum value of the dead-weight load which can be lifted by the testing machine indenter load during each of ten successive trials, and the minimum value which cannot be lifted during any one of ten successive trials, shall be determined. The correct value of the indenting load shall be taken as the average of these two values. The difference between the two values shall not exceed 0.5 per cent of the average value.

D. VERIFICATION BY ELASTIC CALIBRATION DEVICE

Definition of Elastic Calibration Device

12. An elastic calibration device for use in verifying the load readings of a testing machine consists of an elastic member or members to which loads may be applied, combined with a mechanism or device for indicating the magnitude (or a quantity proportional to the magnitude) of deformation under load.

Temperature Equalization

13. When using an elastic calibration device to verify the readings of a testing machine, the device shall be placed near to, or preferably placed in, the testing machine a sufficient length of time before the test so that the device and the testing machine shall be at very nearly the same temperature.

Procedure

14. The elastic device shall be placed in the testing machine so that its center line shall coincide with the center line of the heads of the testing machine, and the machine shall be balanced with no load on the elastic device and a zero reading of the device taken. Test loads shall then be applied at suitable increments. The indicated load of the testing machine and the applied load computed from the readings of the elastic device shall be recorded and the error and the percentage of error calculated from these data.

CALCULATION AND REPORT

Basis of Verification

15. (*a*) The percentage of error for loads within the loading range of the testing machine shall not exceed ±1.0.

NOTE 1.—This means that the report of the verification of a testing machine will state within what loading range it may be used, rather than reporting a blanket acceptance or rejection of the machine.

(*b*) In establishing the lower limit of a loading range below 10 per cent of the capacity of the range where five applications of load are required, the algebraic difference between the highest and lowest percentage of error shall not exceed 1.0.

NOTE 2.—This means that to establish the lower limit of a loading range less than 10 per cent of the capacity of that range, the errors for the series of five readings shall not only not exceed 1 per cent but also no two errors shall differ by more than 1.0 per cent. If the minimum error in this series is −1.0 per cent the maximum error cannot exceed 0.0 per cent; if the minimum error is −0.5 per cent the maximum error cannot exceed +0.5 per cent. If the minimum error is 0.0 per cent the maximum error cannot exceed +1.0 per cent; etc.

(*c*) In no case shall the loading range be stated as including loads below the value which is 100 times the smallest change of load which can be estimated on the load-indicating apparatus of the testing machine.

NOTE 3.—This means that in a testing machine which has graduations so spaced that estimations can be made to 1/10 division, the loading range could not extend downward to a load less than that corresponding to 10 divisions. If the graduations on the load-indicating scale can be estimated only to 2 divisions the loading range could not extend downward below the load corresponding to 200 divisions. On most machines the smallest load that can be measured is somewhere between the two examples cited.

(*d*) In no case shall the loading range be stated as including loads outside the range of loads applied during the verification test.

Corrections

16. The indicated load of a testing machine shall not be corrected either by calculation or by the use of a calibration diagram to obtain values within the required permissible variation.

Time Interval Between Verifications

17. It is recommended that testing machines, when in constant use, be verified at intervals of 6 months and, when used intermittently, at intervals of 2 or 3 years. Testing machines shall, however, be verified immediately after making repairs or adjustments of the weighing mechanism, after the testing machine has been moved (this does not apply to portable testing machines), and whenever there is reason to doubt the accuracy of the results, without regard to the time interval since the last verification.

Report

18. A clear and complete report shall be prepared of each verification of a testing machine. This report shall state the method of verification used, and shall give the serial numbers and the names of manufacturers of all apparatus employed in carrying out the verification. It shall state how, by whom, and when the calibration of the apparatus used in verifying the testing machine was made, the loading range of the calibration apparatus, and the loading range of the testing machine.

Certificate

19. A certificate giving the manufacturer's serial number and a brief description of the testing machine, the manufacturer's name, the date of verification and the loading range shall be signed by the person in responsible charge of the verification.

Standard Methods of

VERIFICATION OF CALIBRATION DEVICES FOR VERIFYING TESTING MACHINES[1]

ASTM Designation: E 74 - 57

(Formerly Part of Methods E 4)

ADOPTED, 1957.[2]

This Standard of the American Society for Testing Materials is issued under the fixed designation E 74; the final number indicates the year of original adoption as standard or, in the case of revision, the year of last revision.

Scope

1. These methods cover procedures for the verification of calibration devices suitable for calibrating testing machines in accordance with the requirements of the Methods of Verification of Testing Machines (ASTM Designation: E 4).[3] Any of the following four devices may be used:

Dead weights,
Proving levers,
Equal-arm balances and standard weights, and
Elastic calibration devices.

DEAD WEIGHTS

Verification of Dead Weights

2. Errors in weights used for the verification of testing machines shall be no greater than 0.1 per cent.

PROVING LEVERS

Design of Proving Levers

3. Proving levers used for verifying testing machines are generally of the type shown in Fig. 1, having knife-edge bearings as shown, plate-fulcra bearings, or other suitable type of bearings. If knife-edge bearings are used, the knife edges, as well as the supports for the knife edges, shall be of hardened steel. The levers shall be so designed that the maximum load on any knife edge shall not exceed 7000 lb per linear inch. The three knife edges in each lever shall be parallel. Each lever shall have a machined surface upon which a spirit level can be placed to show when the plane of the two end knife edges is level; or, in-

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[1] Under the standardization procedure of the Society, these methods are under the jurisdiction of the ASTM Committee E-1 on Methods of Testing.

[2] Prior to adoption as standard, these methods were published as tentative from 1947 to 1957, being revised in 1950 and 1955.

These methods, together with the Tentative Methods of Verification of Testing Machines (E 4 - 57 T), represent a revision of and replace the former Standard Methods of Verification of Testing Machines (E 4 - 36).

[3] Appears in this publication, see Contents in Numeric Sequence of ASTM Designations at front of book.

stead of a machined surface, it is satisfactory to provide two pins of suitable size for supporting a spirit level for this purpose.

Verification of Proving Levers

4. (*a*) The lever ratio of a proving lever shall be determined by the use of at least three test loads. The proving lever shall be balanced over its center bearing with suitable weight trays suspended from the end bearings. Weights shall be suspended from the end bearing of the short arm of the lever amounting to approximately 50 per cent, 75 per cent, and not less than 100 per cent of the weight which, if suspended from the end bearing of the long arm of the lever, would load the lever to its capacity. For each of the three test loads the proving lever shall be brought to balance by small standard weights applied at the end bearing of the long arm of the lever, and by observation of the freely swinging lever. For each test load the ratio of the weight applied at the end bearing of the short arm of the lever to the balancing weight applied at the end bearing of the long arm of the lever shall be calculated. The value of the smallest of the three ratios thus determined shall not differ from the value of the largest of the three ratios by more than 0.1 per cent of the average of the three ratios. Within this tolerance, the average of the three ratios determined from the three test loads is the *lever ratio* of the proving lever.

(*b*) The sensitivity of a proving lever shall be determined by balancing it over its center bearing with a load not less than the largest of the three test loads used in determining the lever ratio, applied to the end bearing of the short arm of the lever. Then a weight of not over 0.002 per cent of the capacity load of the lever shall be added to the weights at the end bearing of the short arm of the lever and a change of slope of the lever of not less than 1 in 60 shall result. This change in slope may be indicated by a suitable spirit level or by a scale and pointer.

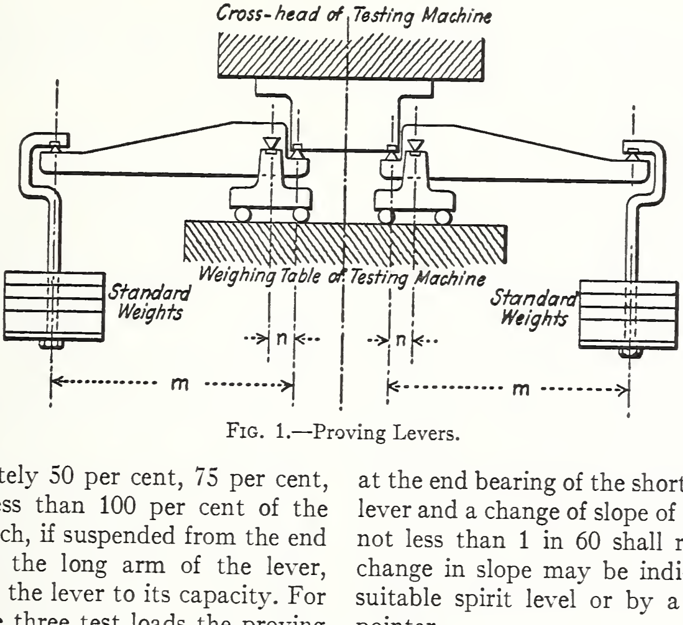
Cross-head of Testing Machine
Weighing Table of Testing Machine
Standard Weights
Standard Weights
n
n
m
m

FIG. 1.—Proving Levers.

(*c*) Weights used for determining the lever ratio of proving levers shall have errors not greater than 0.02 per cent.

(*d*) The deflection of a proving lever under load causes a slight change in lever ratio due to (*1*) the deflection of the bearings, (*2*) the curvature of the longitudinal axis of the lever under load, and (*3*) the rotation of the bearings. When a lever is placed in a testing machine and loaded to capacity, and the deflection of the lever measured at not less than ten locations over the span between the end bearings, the maximum deflection determined shall not exceed 0.067 per cent of the span between the end bearings of the lever. The change of lever ratio for a proving lever with a 10 to 1 lever ratio will be somewhat less than 0.1 per cent under such a maximum deflection.

EQUAL-ARM BALANCE

Design of Balance

5. The balance shall be of the equal-arm type, having either stabilized pans or pans of the suspended type. The balance shall have adequate sensitivity to permit the detection of differences in weight on the two pans of 0.1 per cent of any test load applied during the verification of a machine. The error in the arm ratio of the balance shall not exceed 1 part in 10,000.

ELASTIC CALIBRATION DEVICES

Description of Terms

6. (*a*) *Elastic Calibration Devices.*—An elastic calibration device for use in verifying the load readings of a testing machine consists of an elastic member or members to which loads may be applied, combined with a mechanism or device for indicating the magnitude (or quantity proportional to the magnitude) of deformation under load.

(*b*) *Reading.*—A reading is the indication of the device under no-load or under a load.

(*c*) *Change in Reading.*—The change in reading of the device for any load is the difference between the reading for that load and the reading for no-load.

(*d*) *Calibration Factor.*—The calibration factor is the factor by which the the change in reading must be multiplied to obtain the equivalent load.

NOTE.—The calibration factor for a given change in reading is the ratio of the load to the corresponding change in reading.

(*e*) *Calibration Line.*—The calibration line is a straight line drawn to represent the individually calculated calibration factors plotted as a function of the change in reading of the device.

(*f*) *Error.*—The error of an elastic calibration device is the value obtained by subtracting the calibration factor determined from the calibration line from the corresponding calculated factor.

(*g*) *Percentage of Error.*—The percentage of error is the ratio, expressed as a percentage, of the error to the calibration factor determined from the calibration line.

(*h*) *Loading Range.*—The loading range of an elastic calibration device is the range of indicated loads for which no percentage error of the device exceeds the specified tolerances.

Design and Workmanship

7. An elastic calibration device should be so designed and constructed that its accuracy is not in danger of being impaired by handling, shipping, or ordinary use, and so that parts subject to damage, replacement, or removal for storage and shipment can be replaced without impairing the accuracy of the device.

NOTE.—This section is nonquantitative in its requirements. It is placed in the method for the purpose of calling attention to the fact that an elastic calibration device, if improperly designed and constructed, may, like any other delicate measuring instrument, be damaged and rendered inaccurate by handling and shipping.

Shackles and Bearing Blocks

8. An elastic calibration device shall be provided with shackles, bearing blocks, or any other necessary fixtures through which the load is to be applied to the calibration device. All such fixtures should be so designed and constructed that, when placed in a testing machine in reasonably good condition, there shall be no variations of reading in excess of per-

missible variations due to imperfections in the bearing blocks or in the motion of the head of the testing machine.

NOTE.—This section is nonquantitative in its requirements. It is placed in the method for the purpose of calling attention to the fact that poorly designed loading fixtures can render inaccurate the readings of an elastic calibration device.

Graduation of Scale

9. The scale of the indicating mechanism may be uniformly graduated, or the spacing of the graduations may vary over the length of the scale. The scale need not be continuous on a device designed to determine the errors of indicated loads near certain definite test loads.

Marking

10. The manufacturer's name, the capacity load, and the serial number of the device shall be legibly marked on some part of the instrument.

Temperature Equalization

11. When calibrating an elastic calibration device, the device shall be placed near, or in, the testing machine for a sufficient length of time before the calibration so that the device and the testing machine shall be at very nearly the same temperature during the calibration.

Elimination of Small Temperature Effects Due to Stress

12. If during calibration, errors due to temperature effect of stress and pseudoelastic action as great as 0.05 per cent are observed at the fastest practicable rates of loading and unloading, a time schedule designed to insure that errors due to these causes shall not exceed this value shall be followed and reported. The same time schedule, within limits stated in the report, shall be followed when using the device to calibrate a testing machine.

Primary Standards for Calibrating Elastic Calibration Devices

13. (*a*) *Loads not Exceeding 100,000 lb.*—For loads not exceeding 100,000 lb, an elastic calibration device shall be calibrated by applying dead weights known to have an error not greater than 0.02 per cent.

(*b*) *Loads Exceeding 100,000 lb.*—For loads exceeding 100,000 lb an elastic calibration device may be calibrated by another elastic calibration device or by a combination of several elastic calibration devices. In this case the accuracy of the calibrating load shall be known not to exceed the allowable errors prescribed in Table I.

TABLE I.—REQUIRED ACCURACY OF ELASTIC CALIBRATION DEVICES USED FOR VERIFICATION OF CALIBRATION DEVICES.

Load, lb	Accuracy of Calibrating Load, per cent
Over 100 000 to 300 000, incl.	0.1
Over 300 000 to 1 000 000, incl.	0.2
Over 1 000 000 to 3 000 000, incl.	0.3
Over 3 000 000	0.4

Preliminary Overload Test

14. Before taking readings for the first formal verification of an elastic calibration device by means of dead weights or other primary standards, the device shall be subjected to a series of cyclic loads varying from a minimum load not greater than 2 per cent of the capacity load of the device to a maximum load not less than 5 nor more than 10 per cent above the nominal capacity load.

Routine in Calibration of Elastic Calibration Device

15. For any range of test loading which may be applied in calibrating an elastic

calibration device, there shall be applied at least eight test loads, and the difference between any two successive test loads shall not exceed one fifth of the difference between the minimum and maximum test loads.

For any ordinary or precision loading range the elastic calibration device shall be verified by at least five different test loads. No ordinary loading range shall include loads below the load corresponding to 25 scale divisions or 500 times the minimum estimated change in reading, whichever is the greater. No precision loading range shall include loads below the load corresponding to 50 scale divisions or 1000 times the minimum estimated change in reading, whichever is the greater. The series of test loads shall be applied to the elastic calibration device at least three times, and the shackles or bearing blocks shall be readjusted before each application of a series of loads. After the application of at least one series of loads and before the application of the next series of loads, adjustments shall be made to change the no-load reading of the device, provided the device is so constructed as to permit the no-load reading to be changed readily and without disassembly. Devices which are normally set to indicate no-load before the application of a test load shall be reset to indicate no-load after movement of the adjustment control.

NOTE.—In the case of some devices having deflection-measuring apparatus which includes a micrometer screw, the complete micrometer screw may be rotated to change the no-load reading of the device. In the case of an Amsler box, the fiduciary mark to which the meniscus of the mercury column is set may be moved along the capillary tube. In the case of some devices having deflection-measuring apparatus which includes a dial micrometer, the graduated scale of the dial micrometer may be moved with respect to the mechanism, or the position of the spindle of the dial micrometer may be adjusted to rotate the pointer to the desired position, or both. In the case of devices whose deflections are indicated by readily removable dial micrometers with fixed dial scales and no means of changing the no-load reading except by modifying the fixtures, the no-load reading need not be changed. For such devices the dial micrometers may be removed after one series of test loads, and then replaced before the next series.

Loading Procedure

16. The elastic calibration device shall be calibrated under increasing loads. Tensile and compressive loads, except as provided in Section 17, shall be applied through bearing blocks and shackles provided with the device.

Bearing Plate Test

17. The change in reading of the device for the maximum load applied by dead weights during the calibration shall be determined when the device is loaded, through plane, concave, and convex bearing blocks. The radii of curvature of the spherical surface of the concave and convex bearing blocks shall be not less than 9 ft and not more than 10 ft. The differences between the average change in reading observed using the plane bearing block and the concave block, and the average changes in reading observed using the plane bearing block and the convex block shall not exceed 0.1 per cent for devices reported to have a precision loading range, or 0.25 per cent for devices reported to have an ordinary loading range.

NOTE.—These tests need not be made on a device previously found to comply with the requirements of this paragraph.

Tolerances for Elastic Calibration Devices

18. (*a*) For ordinary use, the loading range of an elastic calibration device shall be that range of load within which no calibration factor differs by more than the amount prescribed in Table II from the corresponding factor indicated by the calibration line for the same change in indicated reading of the device.

(*b*) The report of the verification of

an elastic calibration device not exceeding 300,000-lb capacity shall also state the precision loading range within which no calibration factor deviated by more than 0.1 per cent from the corresponding factor indicated by the calibration line for the same change in indicated reading of the device.

(*c*) *Devices Equipped With Dial Micrometers, Without Provision for Adjustment of the No-Load Readings.*—For elastic calibration devices whose deflections are indicated by dial micrometers with fixed dial scales without provision for adjusting the no-load readings except by modifying the fixtures, calibration lines need not be determined. The device may be used *for those loads* for which no change in reading differed from the average change in reading for the calibration test load by more than the numerical tolerances prescribed in Paragraphs (*a*) and (*b*) and Table II, provided that the no-load readings of the device differ from the median value of no-load readings observed during the last calibration by not more than one fortieth of one revolution of the pointer of the dial micrometer.

TABLE II.—TOLERANCES FOR THE LOADING RANGE OF ELASTIC CALIBRATION DEVICES FOR ORDINARY USE.

Capacity Load of Device, lb	Tolerance Requirements for Loading Range, per cent
300 000 and under	0.25
Over 300 000 to 1 000 000, incl.	0.3
Over 1 000 000 to 3 000 000, incl.	0.4
Over 3 000 000 to 10 000 000, incl.	0.5

Temperature Correction for Elastic Calibration Devices

19. In using an elastic calibration device made of steel with not more than 5 per cent of alloying elements, a fairly accurate correction for variations in temperature may be made on the basis that the change in reading of the device increases by 0.015 per cent for each degree Fahrenheit increase in temperature.

NOTE.—In tests made at the National Bureau of Standards the temperature coefficients of a group of 14 proving rings for the temperature range 70 to 100 F were found to average −0.00015 per deg Fahr. Individual values range from −0.000123 to −0.000160 per deg Fahr. The temperature coefficient of one Amsler box for the temperature range 70 to 100 F was found to be −0.00012 per deg Fahr. For a temperature difference of 30 F, the maximum likely to be encountered in ordinary use, the use of a coefficient value of −0.00012 instead of −0.00015 per deg Fahr would change the resulting calculated load by 0.09 per cent.

Time Interval Between Calibrations

20. Elastic calibration devices shall be calibrated at intervals not exceeding 2 yr. Devices shall, however, be calibrated immediately after being overloaded or repaired.

Report

21. A clear and complete report shall be prepared of each calibration of an elastic calibration device. This report shall state the method of calibration used and shall give the serial numbers, the names of the manufacturers, and the dates of calibration of any elastic calibration devices employed. For devices stated to comply with Section 18 (*a*) and (*b*), the report shall include a calibration graph on which the calibration line and the experimentally determined calibration factors are shown, and shall state the ordinary and precision-loading ranges of the elastic calibration device. For devices stated to comply with Section 18 (*c*), the report shall include a table of the changes in reading observed for each test load and shall state the specific loads for which the elastic calibration device may be used.

Tentative Methods of
VERIFICATION AND CLASSIFICATION OF EXTENSOMETERS[1]

ASTM Designation: E 83 – 57 T

Issued, 1950; Revised, 1952, 1957.[2]

This Tentative Method has been approved by the sponsoring committee and accepted by the Society in accordance with established procedures, for use pending adoption as standard. Suggestions for revisions should be addressed to the Society at 1916 Race St., Philadelphia 3, Pa.

Note.—Editorial changes were made in Sections 1 and 5, and former Note 1 under Section 1 was deleted in August, 1958.

Scope

1. This method covers procedures for the verification and classification of extensometers, but it is not intended to be a complete purchase specification for extensometers. The method is applicable only to instruments that indicate or record values which are proportional to changes in length. Extensometers are classified on the basis of the magnitude of their errors.

Note.—Wire strain gages cannot be calibrated with the apparatus described in this method for the calibration of extensometers having definite gage points. Individual wire gages may be attached to test bars or strips and calibrated by means of extensometers calibrated as described in this method.[3] The quality control and calibration procedures used by the manufacturer of SR-4 strain gages are described in Appendix II.

Definitions

2. (*a*) *Extensometer.*—A device for measuring strain, of either the indicating or recording type.

(*b*) *Strain.*—The change per unit of length in a linear dimension of a body, which change accompanies a stress. Strain is a dimensionless quantity which may be measured conveniently in per cent, in inches per inch, in millimeters per millimeter, etc.

(*c*) *Gage Length.*—The linear distance over which the change in length is measured.

Note.—For some extensometers the gage length is fixed by the positions of gage marks, while for others the gage length is adjustable and must be set for the desired gage length when the extensometer is attached to the specimen.

(*d*) *Calibration Factor.* The factor by which the change in extensometer reading must be multiplied to obtain the equivalent strain.

Note.—For any extensometer the calibration factor is equal to the ratio of change in length to the product of the gage length and the change in the extensometer reading. For direct reading extensometers the calibration factor is unity.

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[1] Under the standardization procedure of the Society, this method is under the jurisdiction of the ASTM Committee E-1 on Methods of Testing.

[2] Revision accepted by the Society at the Annual Meeting June, 1957.

[3] Such a procedure is described by W. R. Campbell, "Performance Tests of Wire Strain Gages, I—Calibration Factors in Tension." Technical Note 954, Nat. Advisory Committee for Aeronautics.

(*e*) *Error.*—In the case of an extensometer, the value obtained by subtracting the correct value of the strain from the indicated value given by the extensometer.

(*f*) *Calibration Apparatus.*—A device for calibrating extensometers consists of a mechanism to which extensometers may be attached and a means for measuring accurately changes in length.

Calibration Apparatus

3. The apparatus for calibrating extensometers shall provide a means for applying controlled displacements to the extensometer and for measuring these displacements accurately. It may consist of a rigid frame, suitable coaxial spindles, or other fixtures to which the extensometer may be attached, a mechanism for moving one spindle or fixture axially with respect to the other, and a means for measuring accurately the change in length so produced,[4] or any other device or mechanism that will accomplish the purpose equally well. The mechanism provided for moving one spindle relative to the other shall permit sensitive adjustments. The changes in length shall be measured by means of an interferometer, calibrated standard gage blocks and an indicator, or a micrometer screw. If standard gage blocks and an indicator, or a micrometer screw, are used, they shall be calibrated and their limits of accuracy and sensitivity stated. The errors of the calibration apparatus shall not exceed one-fifth of the permissible error of the extensometer.

Assembly of Calibration Apparatus

4. (*a*) *Position of Extensometer During Calibration.*—The position of the extensometer during calibration shall preferably be the same as the position of the extensometer when it is attached to a test specimen, in order to avoid errors due to lack of balance or deformation of the parts of the extensometer.

NOTE.—The position of the extensometer during calibration has more effect on the calibration results for some types of instruments than for others. If for a given type of extensometer careful tests have shown the effect of position during calibration to be negligible, the position during calibration need not be the same as the position of the extensometer when it is attached to a test specimen.

(*b*) *Method of Attaching Extensometer.*—The extensometer shall be supported during calibration in the same way it is supported when it is attached to a test specimen.

(*c*) *Temperature Control.*—The extensometer shall be calibrated at approximately the temperature at which it is used. It shall be placed near or mounted on the calibration apparatus a sufficient length of time before calibration so that the parts of the calibration device to which the extensometer is attached and the extensometer shall be at very nearly the same temperature. If the calibration is made at room temperature the temperature of the room should be kept as nearly constant as possible during the calibration.

(*d*) *Method of Reading.*—The instrument shall be read or, in the case of an autographic extensometer, the record shall be measured, in the same manner as during use.

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[4] A complete description of an extensometer comparator with which the changes in length may be measured either by means of standard gage blocks and an indicator or by means of the interferometer method is given in a paper by A. H. Stang and L. R. Sweetman, "An Extensometer Comparator," *Journal of Research*, Nat. Bureau Standards, Vol. 15, No. 3, September, 1935, p. 199 (Research Paper RP822).

A description of an extensometer calibrating device which makes use of a calibrated differential micrometer screw is given in a paper by R. L. Templin, "The Calibration of Extensometers," *Proceedings*, Am. Soc. Testing Mats., Vol. 28, Part II, p. 714 (1928).

A description of a method of calibrating extensometers by means of a calibration bar loaded in a testing machine is given in a paper by W. C. Aber and F. M. Howell, "A Method of Calibrating Extensometers," ASTM BULLETIN, No. 155, December, 1948, p. 33.

NOTE.—If an extensometer is equipped with a dial micrometer, it may be desirable or necessary to tap or vibrate the dial micrometer to minimize the effects of friction and to insure that the most stable and reproducible readings are obtained. If the dial micrometer is tapped or vibrated the report shall so state and the dial shall be tapped or vibrated during use of the extensometer.

Range of Calibration

5. Extensometers are to be calibrated throughout the full range used in testing and shall be classified accordingly. They need not be calibrated beyond the range over which they are to be used. Extensometers having more than one range shall be verified and classified for each range to be used. The classification need not be the same for all ranges.

NOTE.—Extensometers shall not be used for measuring a greater value of strain than that for which they have been calibrated. Extensometers calibrated only for increasing strain shall not be used for measuring decreasing strain and *vice versa.*

Number of Observations

6. (*a*) *Number of Readings.*—The reading of the extensometer shall be observed for at least ten different readings of the calibration apparatus. The interval between any two successive readings shall not exceed one-eighth of the difference between the minimum and maximum readings.

NOTE 1.—For a calibration of a Tuckerman strain gage over a range which involves the use of both the tension and compression images, the interval between the last reading before one image disappears from view and the first reading after the other image appears in view shall not exceed one-third of the range over which the gage is calibrated.

NOTE 2.—If the connection between the gage points attached to the specimen and the indicating device is made through geared wheels or micrometer screws, relatively large periodic errors may exist which might not be disclosed by this over-all calibration. For such extensometers it may be necessary to take additional readings within one turn of any geared wheel, micrometer screw, or the travel of one tooth of any meshing gear.

(*b*) *Number of Runs.*—Two complete sets of extensometer readings shall be taken for the same changes in length. The extensometer shall be removed from the calibration apparatus and then replaced between runs.

Calibration Factor

7. The calibration factor or factors of the extensometer shall be determined graphically or algebraically from the extensometer readings and the ratios of the changes in length of the calibration apparatus to the gage length of the extensometer.

Errors

8. The error of the extensometer shall be calculated for each change in length of the calibration apparatus.

Classification

9. Extensometers shall be classified in accordance with the following requirements as to maximum error of indicated strain:

	Maximum Error of Indicated Strain
Class A	0.00001
Class B-1	0.0001
Class B-2	0.0002
Class C	0.001
Class D	0.01
Class E	0.1

NOTE.—Class A extensometers would ordinarily be used for determining precise values of the modulus of elasticity and for delicate measurements of permanent set or very slight deviations from Hooke's Law. Class B-1 extensometers would ordinarily be used for determining values of the modulus of elasticity and for measurement of permanent set or deviations from Hooke's Law and for determining values such as the yield strength of metallic materials. Class B-2 extensometers would be used for determining yield strength of metallic materials. This classification would generally apply to extensometers having gage lengths less than 2 in. which would not meet Class B-1 requirements. Definitions of the terms "modulus of elasticity" and "yield strength" are given in the Definitions of Terms Relating to Methods of Mechanical Testing (ASTM Designation: E 6).[5]

Report

10. The report shall include the following:

(*1*) Method of verification used,

(*2*) Serial numbers and names of the manufacturers of all apparatus used in verifying the extensometer,

(*3*) A statement indicating how, by whom, and when the calibration of the apparatus used in verifying the extensometer was made,

(*4*) A statement of the errors of the calibration apparatus,

(*5*) Serial number, if any, and name of the manufacturer of the extensometer verified.

(*6*) Gage length of the extensometer,

(*7*) Position of the extensometer during calibration,

(*8*) Temperature of the extensometer during calibration,

(*9*) Method of attaching the extensometer to the calibration apparatus,

(*10*) Complete record of the readings of the extensometer and of the calibration apparatus,

(*11*) Calibration factor,

(*12*) Error of the extensometer for each extensometer reading, and

(*13*) Class of the extensometer.

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[5] 1958 Book of ASTM Standards, Parts 3, 4, 5, 6, 9, 10.

APPENDIX I

EXAMPLE OF PROCEDURE FOR VERIFICATION AND CLASSIFICATION OF EXTENSOMETERS

The data obtained for a typical indicating extensometer during calibration are given in the first four columns of Table I. The results calculated from these data are given in columns 5 to 8, inclusive, of Table I, and have been plotted in Fig. 1.

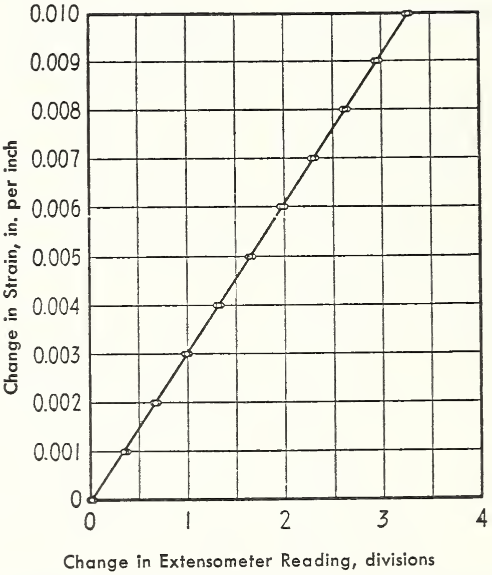

FIG. 1.—Relation of Changes in Extensometer Readings and in Strain.

The indicated strains, obtained by multiplying each change in extensometer reading by the calibration factor are given in Table II. The error for each change in extensometer reading is also given in Table II and is plotted in Fig. 2.

The calibration factor given in Table I was calculated from the results in columns 5 to 8, inclusive, of Table I by the method of least squares. The calibration factor is proportional to the slope of the line drawn to represent the observed points in Fig. 1 and could, of course have been determined from the graph.

Since the maximum error given in columns 5, 6, and 7 of Table II does not exceed 0.00005, the extensometer is classified as a class B-1 extensometer.

The data for a typical autographic extensometer are given in Fig. 3.

Unless careful tests have shown that autographic extensometers and recorders of a given type may be used interchangeably without introducing errors which would affect the classification of the extensometer, the extensometer shall be calibrated with the recorder with which it is to be used.

P-40-41

TABLE I.—CALIBRATION DATA FOR A TYPICAL EXTENSOMETER.

Calibration apparatus used Johansson Blocks with error not more than 0.000004 in., indicator sensitivity 0.000005 in.

Change in Length, in.	Extensometer Reading, Divisions			Change in Strain, in. per in.	Change in Extensometer Reading		
	Run No. 1	Run No. 2	Run No. 3		Run No. 1	Run No. 2	Run No. 3
1	2	3	4	5	6	7	8
0.00000.......	−0.09	−0.015	−0.055	0.00000.......	0.000	0.000	0.000
0.00100.......	0.245	0.32	0.275	0.00100.......	0.335	0.335	0.33
0.00200.......	0.57	0.65	0.60	0.00200.......	0.66	0.665	0.655
0.00300.......	0.895	0.97	0.92	0.00300.......	0.985	0.985	0.975
0.00400.......	1.22	1.295	1.25	0.00400.......	1.31	1.31	1.305
0.00500.......	1.555	1.625	1.58	0.00500.......	1.645	1.64	1.635
0.00500.......	−0.08	−0.08	−0.095	....	...	...	...
0.00600.......	0.265	0.26	0.25	0.00600.......	1.99	1.98	1.98
0.00700.......	0.60	0.595	0.585	0.00700.......	2.325	2.315	2.315
0.00800.......	0.92	0.915	0.905	0.00800.......	2.645	2.635	2.635
0.00900.......	1.25	1.24	1.23	0.00900.......	2.975	2.96	2.96
0.01000.......	1.58	1.565	1.555	0.01000.......	3.305	3.285	3.285

Calibration factor = 0.003033

NOTE.—Measured gage length = 1.000 in.

TABLE II.—ERRORS OF EXTENSOMETER READINGS.

Change in Strain, in. per in.	Indicated Strain			Error		
	Run No. 1	Run No. 2	Run No. 3	Run No. 1	Run No. 2	Run No. 3
1	2	3	4	5	6	7
0.00000...........	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
0.00100...........	0.00102	0.00102	0.00100	0.00002	0.00002	0.00000
0.00200...........	0.00200	0.00202	0.00199	0.00000	0.00002	−0.00001
0.00300...........	0.00299	0.00299	0.00296	−0.00001	−0.00001	−0.00004
0.00400...........	0.00397	0.00397	0.00396	−0.00003	−0.00003	−0.00004
0.00500...........	0.00499	0.00497	0.00496	−0.00001	−0.00003	−0.00004
0.00600...........	0.00604	0.00601	0.00601	0.00004	0.00001	0.00001
0.00700...........	0.00705	0.00702	0.00702	0.00005	0.00002	0.00002
0.00800...........	0.00802	0.00799	0.00799	0.00002	−0.00001	−0.00001
0.00900...........	0.00902	0.00898	0.00898	0.00002	−0.00002	−0.00002
0.01000...........	0.01002	0.00996	0.00996	0.00002	−0.00004	−0.00004

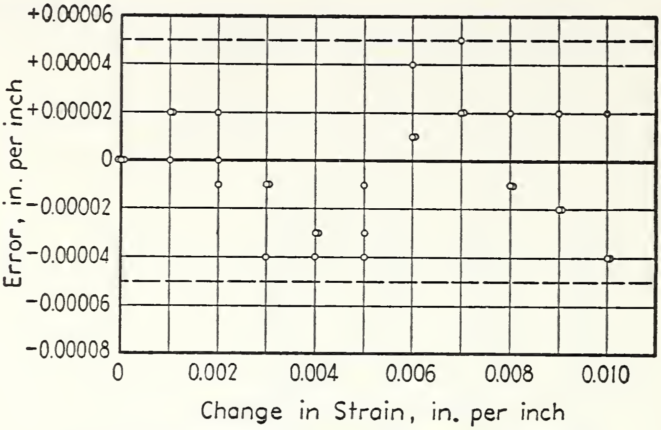

FIG. 2.—Error for Each Change in Extensometer Reading.

1. METHOD OF CALIBRATION
   Extensometer Comparator
2. SOURCE OF CALIBRATION APPARATUS
   Comparator – ABC Co.
   Gage Blocks–XYZ Co.
   Optimeter — John Doe Co.
3. VERIFICATION OF CALIBRATION APPARATUS
   Gage Blocks – Nat'l. Bureau of Standards – Jan. 7, 1949
   Optimeter – Nat'l. Bureau of Standards – Jan. 7, 1949
4. ERRORS OF CALIBRATION APPARATUS
   Max. Error 0.00001"
5. IDENTIFICATION OF EXTENSOMETER
   John Brown Co. Model T-1M Serial No. 1683
6. GAGE LENGTH OF EXTENSOMETER – 2.0"
7. POSITION OF EXTENSOMETER DURING CALIBRATION
   Attached to 0.500" Spindles with Axis Vertical
8. TEMPERATURE OF EXTENSOMETER
   During Calibration – 70 F
9. METHOD OF ATTACHMENT TO CALIBRATION APPARATUS
   As Per Manufacturer's Instructions for Service Use
10. RECORD OF READINGS
    As Per Graph
11. CALIBRATION FACTOR – 0.001
12. ERROR OF EXTENSOMETER FOR EACH READING
    As Measured on Graph – Max. Error 0.00008"
    (At 0.020")
13. CLASS OF EXTENSOMETER – B-1
14. DATE OF CALIBRATION – JAN. 4, 1950

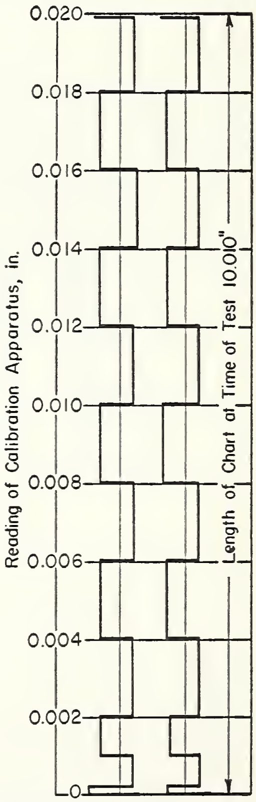

FIG. 3.—Typical Record and Report for Autographic Extensometer.

APPENDIX II

QUALITY CONTROL AND CALIBRATION PROCEDURE FOR WIRE STRAIN GAGES

The wire resistance strain gages of the SR-4 type are manufactured and calibrated in a building which is maintained at a constant temperature (74 ± 1 F) and controlled humidity, preferably below 40 per cent relative humidity. After completion of manufacture and a preliminary physical inspection, one sample gage out of approximately every fifty is subjected to calibration for the determination of gage factor (ratio of unit resistance change to unit strain change or ohms per ohm divided by inches per inch).

The calibration apparatus, which is shown schematically in Fig. 4, consists essentially of a composite steel beam approximately 13 ft in total length, simply supported on two knife edges 12 ft, 7 in. apart. One knife edge is fixed while the other is supported on rollers to allow freedom of motion under simple bending. The center portion of this beam consists of a removable section 1 by 2 by 36 in. long called a "calibrating beam," leaving a 27-in. free length for installing gages. The gages to be calibrated are attached to the "calibrating beam" in accordance with the manufacturer's recommended techniques. Sometimes as many as twenty gages are tested at one time. The set of dead loads of approximately 100 lb each is applied at fixed distances from the knife edges so that there is a constant bending moment existing along the 27-in. free length of the "calibrating beam."

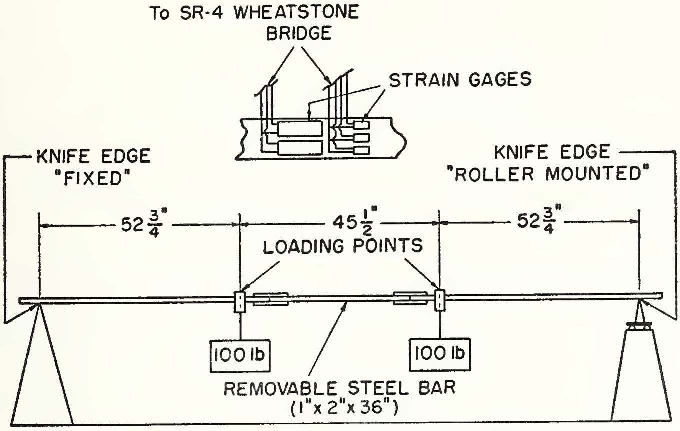
To SR-4 WHEATSTONE BRIDGE
STRAIN GAGES
KNIFE EDGE "FIXED"
KNIFE EDGE "ROLLER MOUNTED"
52 3/4"
45 1/2"
52 3/4"
LOADING POINTS
100 lb
100 lb
REMOVABLE STEEL BAR (1"x 2"x 36")

FIG. 4.—Calibration Apparatus for Wire Strain Gages.

The "calibrating beam" is originally calibrated using a Tuckerman optical strain gage while installed in the calibration apparatus exactly as used. The entire 27 in. of free length of the beam is examined both in a longitudinal and transverse direction in order to determine the Poisson's ratio of this beam. Under the fixed loading conditions it was determined that along the 27-in. free length, the strain applied to the gage filament is 593 microinches. This strain is used in all calibration work as identical loads are always applied.

After the known strain of 593 microinches is applied to the sample gages being calibrated, the changes in resistance of the individual gages are determined on a special type of Wheatstone bridge utilizing a steplessly adjustable resistor comprised of other SR-4 strain gages attached to a small bending beam. The beam is deflected by a micrometer screw. Changes in resistance are obtained from the micrometer readings using the relationship between micrometer readings and resistance changes determined in a previous calibration.

Usual practice is to determine the gage factor of the individual gages to within ±0.5 per cent to permit a guarantee of the gage factor to within ±1 per cent. This holds true for all flat grid type gages. The guarantee varies from ±1 per cent to ±3 per cent for other types depending upon the style and construction. Factors and guaranteed accuracies are stated on the individual packages of gages.

APPENDICES

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GRADUATE OF, OR ATTENDED...
Name of College or University

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